Appendix K – Wilderness Review

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Wilderness Review: Bear Valley, Tule Lake, Upper Klamath, Lower Klamath, and Clear Lake NWRs

The purpose of a wilderness review is to identify and recommend for Congressional designation National Wildlife Refuge System (System) lands and waters that merit inclusion in the National Wilderness Preservation System (NWPS). Wilderness reviews are a required element of comprehensive conservation plans (CCPs) and conducted in accordance with the refuge planning process outlined in 602 FW 1 and 3, including public involvement and the National Environmental Policy Act (NEPA) compliance.

There are three phases to the wilderness review: 1) inventory, 2) study; and 3) recommendation. Lands and waters that meet the minimum criteria for wilderness are identified in the inventory phase. These areas are called wilderness study areas (WSAs). WSAs are evaluated through the CCP process to determine their suitability for wilderness designation. In the study phase, a range of management alternatives are evaluated to determine if a WSA is suitable for wilderness designation or management under an alternate set of goals and objectives that do not involve wilderness designation. The recommendation phase consists of forwarding or reporting recommendations for wilderness designation from the Director through the Secretary and the President to Congress in a wilderness study report.

If the review does not identify any areas that meet the WSA criteria, we document our findings in the administrative record for the CCP, fulfilling the planning requirement for a wilderness review. We inventoried Service lands and waters within Bear Valley, Tule Lake, Upper Klamath, Lower Klamath, and Clear Lake NWRs and found three areas that meet the eligibility criteria for a WSA as defined by the Wilderness Act. This appendix summarizes the wilderness review for these five refuges.

Inventory Criteria

The wilderness inventory is a broad look at the planning area to identify WSAs. These are roadless areas that meet the minimum criteria for wilderness identified in Section 2(c) of the Wilderness Act.

"A wilderness, in contrast with those areas where man and his works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions, and which: (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological or other features of scientific, educational, scenic, or historical value."

A WSA must be a roadless area or island, meet the size criteria, appear natural, and provide outstanding opportunities for solitude or primitive recreation. The process for identification of roadless areas and application of the wilderness criteria are described in the following sections.

Identification of Roadless Areas and Roadless Islands
Identification of roadless areas and roadless islands required gathering and evaluating land status maps, land use and road inventory data, and aerial and satellite imagery for the refuges. "Roadless" refers to the absence of improved roads suitable and maintained for public travel by means of motorized vehicles primarily intended for highway use. Only lands currently owned by the Service in fee title or BLM lands managed under a cooperative agreement were evaluated.

Evaluation of the Size Criteria
Roadless areas or roadless islands meet the size criteria if any one of the following standards applies:

- An area with over 5,000 contiguous acres. State and private lands are not included in making this acreage determination.

- A roadless island of any size. A roadless island is defined as an area surrounded by permanent waters or that is markedly distinguished from the surrounding lands by topographical or ecological features.

- An area of less than 5,000 contiguous Federal acres that is of sufficient size as to make practicable its preservation and use in an unimpaired condition, and of a size suitable for wilderness management.

- An area of less than 5,000 contiguous Federal acres that is contiguous with a designated wilderness, recommended wilderness, or area under wilderness review by another Federal wilderness managing agency such as the Forest Service, National Park Service, or Bureau of Land Management.

Evaluation of the Naturalness Criteria
In addition to being roadless, a WSA must meet the naturalness criteria. Section 2(c) defines wilderness as an area that "... generally appears to have been affected primarily by the forces of nature with the imprint of man's work substantially unnoticeable." The area must appear natural to the average visitor rather than "pristine." The presence of historic landscape conditions is not required. An area may include some human impacts provided they are substantially unnoticeable in the unit as a whole. Significant human-caused hazards, such as the presence of unexploded ordnance from military activity, and the physical impacts of refuge management facilities and activities are also considered in evaluation of the naturalness criteria. An area may not be considered unnatural in appearance solely on the basis of the "sights and sounds" of human impacts and activities outside the boundary of the unit.

Evaluation of Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation
In addition to meeting the size and naturalness criteria, a WSA must provide outstanding opportunities for solitude or primitive recreation. The area does not have to possess outstanding opportunities for both solitude and primitive and unconfined recreation, and does not need to have outstanding opportunities on every acre. Further, an area does not have to be open to public use and access to qualify under this criteria; Congress has designated a number of wilderness areas in the Refuge System that are closed to public access to protect resource values.

Opportunities for solitude refer to the ability of a visitor to be alone and secluded from other visitors in the area. Primitive and unconfined recreation means non-motorized, dispersed outdoor recreation activities that are compatible and do not require developed facilities or mechanical transport. These primitive recreation activities may provide opportunities to experience challenge and risk; self reliance; and adventure.

These two "opportunity elements" are not well defined by the Wilderness Act but, in most cases, can be expected to occur together. However, an outstanding opportunity for solitude may be present in an area offering only limited primitive recreation potential. Conversely, an area may be so attractive for recreation use that experiencing solitude is not an option.

Evaluation of Supplemental Values
Supplemental values are defined by the Wilderness Act as "...ecological, geological, or other features of scientific, educational, scenic, or historic value." These values are not required for wilderness but their presence should be documented.

Inventory Findings:

Bear Valley NWR

As documented below, Bear Valley NWR does not meet the criteria necessary for a WSA.

Roadless Areas and Roadless Islands
Bear Valley Refuge was established in 1978 to protect a vital night roost site for wintering bald eagles. The Refuge consists of 4,200 acres, with much of the Refuge bisected by roads, making the size unsuitable for consideration as wilderness. The largest area without roads is approximately 2,494 acres.

Naturalness Criteria
The Refuge consists primarily of old growth ponderosa pine, incense cedar, white and Douglas fir. These mature stands of trees have open branching patterns of large limbs which allow easy eagle access and can support many birds. Located on a northeast slope, the roost also shelters these raptors from harsh and prevailing winter winds. In recent years, as many as 300 bald eagles have used the roost in a single night. Bear Valley Refuge also serves as nesting habitat for several bald eagle pairs.

Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation
Bear Valley Refuge is closed to all public entry, except for walk-in deer hunting before November 1, to reduce disturbance to the eagles. From December through mid-March excellent opportunities are available from outside the Refuge to observe early morning fly-outs of large numbers of bald eagles and other raptors from their Bear Valley roost.

Supplemental Values
Bear Valley NWR does contain features of scientific, educational, scenic, and historical value. However, Bear Valley NWR does not meet the overall criteria for recommendation as a wilderness area because:

- Much of the Refuge has been bisected by roads;
- It does not encompass 5,000 contiguous acres.

Tule Lake NWR

As documented below, one of the roadless areas at Tule Lake NWR meets the criteria necessary for a WSA.

Roadless Areas and Roadless Islands
Tule Lake NWR consists of 39,117 acres, with approximately 19,000 acres used as croplands, over 10,000 acres of open water and nearly 10,000 acres of wetlands and uplands. Using a geographic information system to model roadless areas, only one roadless area is large enough for consideration as a WSA. The WSA consists of 9,346 acres within Tule Lake NWR, and it consists of primarily open water, completely within Sump 1(A).

Naturalness Criteria
Tule Lake Refuge consists of two open water sumps (reservoirs totaling 13,000 acres) surrounded by croplands. A portion (currently, about 17,000 acres) of the surrounding area is farmed by Reclamation lessees. Refuge permittees farm another 1,903 acres of cereal grain also. This crop, together with the waste grain and potatoes from the lease program, is a major food source for migrating and wintering geese and other field-feeding waterfowl. Irrigation water is managed by the Tulelake Irrigation District under a contract with Reclamation.

Motorized and non-motorized boats use the open waters of the refuge for hunting waterfowl. Currently, motorized boating is authorized within these 9,346 acres.

Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation
When experiencing the refuge outside of the hunt seasons there are opportunities for solitude, although agricultural activities on the shore may disrupt solitude at times.

Supplemental Values
The refuge is a significant staging area for migrating waterfowl during spring and fall migrations. It is used primarily by white-fronted, snow, Ross, and cackling Canada geese, all of which nest in the Arctic tundra. Tule Lake hunting opportunities consist of two large marsh units accessible by boats, a spaced-blind hunt in dry fields, and open free-roam areas offering field hunts over harvested grain and smaller marsh units.

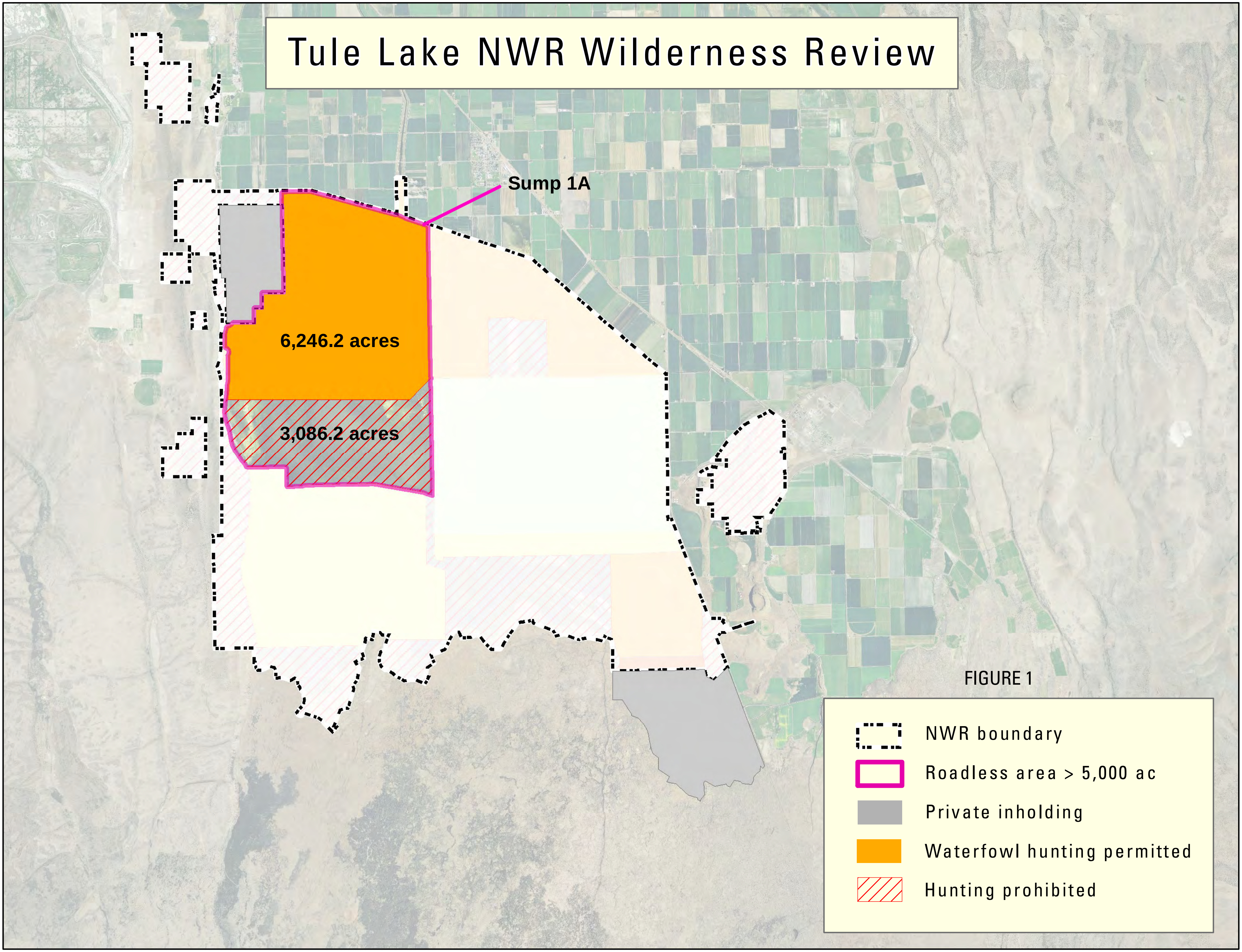

Tule Lake NWR Wilderness Review
Sump 1A
6,246.2 acres
3,086.2 acres
NWR boundary
Roadless area > 5,000 ac
Private inholding
Waterfowl hunting permitted
Hunting prohibited

FIGURE 1

Upper Klamath NWR

As documented below, a roadless area with in the Upper Klamath NWR meets the criteria necessary for a WSA.

Roadless Areas and Roadless Islands/Size Criteria
Upper Klamath Refuge was established in 1928 and is comprised of 23,098 acres of mostly freshwater marsh and open water. Using a geographic information system to model roadless areas, only one roadless area is large enough for consideration as a WSA. The roadless area totals 12,862 acres, and is predominately marshlands and open water. Currently, motorized boating is authorized within these 12,862 acres.

Naturalness Criteria
Upper Klamath Lake, which is the largest freshwater lake solely in Oregon, is very shallow and has extensive wetlands within and immediately adjacent to the natural lake area. Historically, there were up to 52,000 acres of marshland associated with Upper Klamath Lake and up to 65,000 acres of open water at maximum capacity. Lake levels were controlled by two basalt reefs in the upper part of the Link River above the current location of the dam. Prior to construction of the dam and channelization of the reefs, lake levels varied from about 4,140 to 4,143 feet, with a mean annual variation of about two feet.

These habitats serve as excellent nesting and brood rearing areas for waterfowl and colonial nesting birds including American white pelican and several heron species. Bald eagle and osprey nest nearby and can sometimes be seen fishing in Refuge waters.

Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation
A boat is a must for those who wish to explore this refuge. A marked canoe trail is open year round and canoes may be rented nearby.

Supplemental Values
The Refuge's managed water also provides regionally significant ecological value for migratory birds and other wildlife.

Upper Klamath NWR Wilderness Review

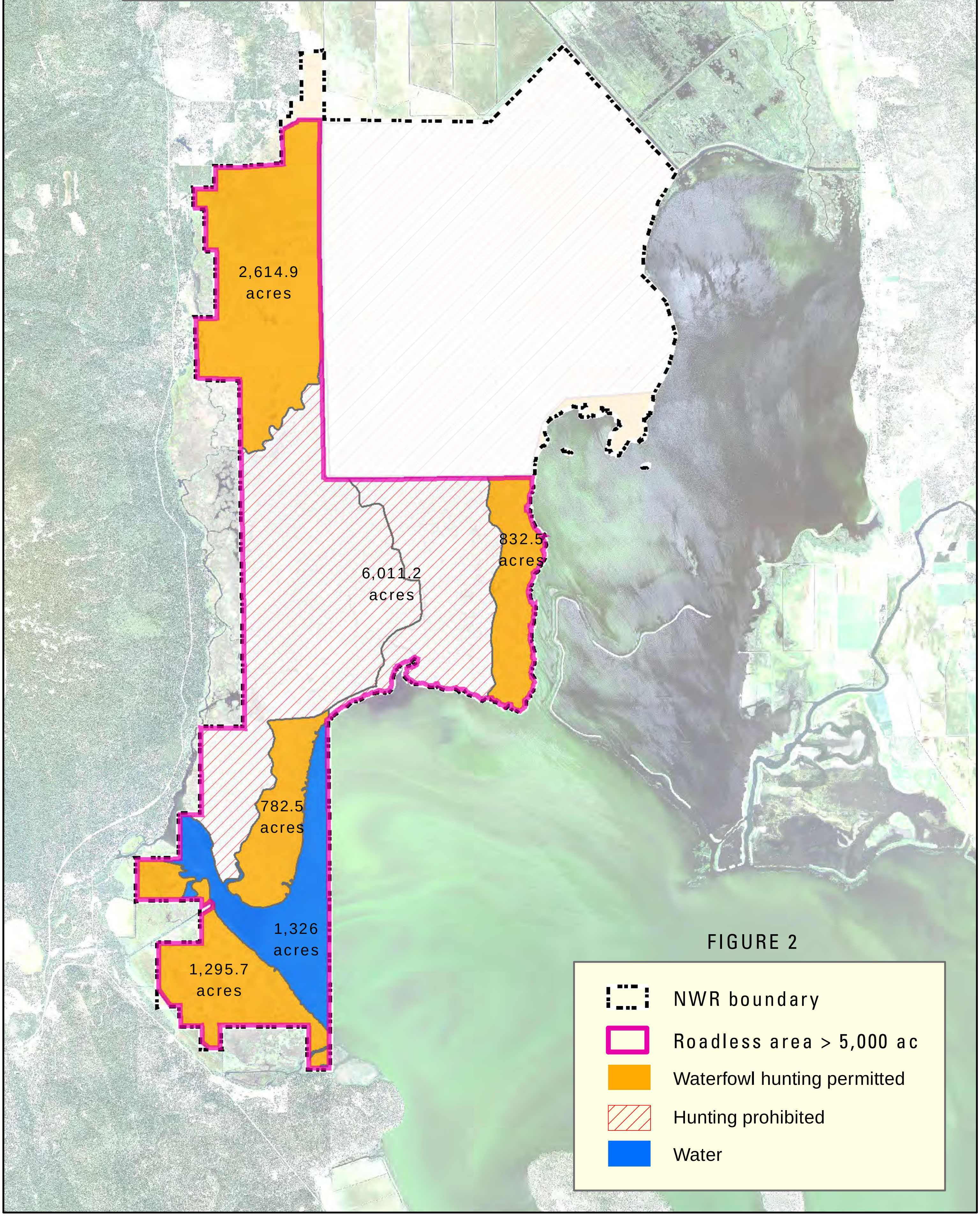


FIGURE 2

Lower Klamath NWR

As documented below, the roadless areas within Lower Klamath NWR do not meet the criteria necessary for a WSA.

Roadless Areas and Roadless Islands
The Lower Klamath NWR consists of approximately 50,912 acres, and is a varied mix of shallow freshwater marshes, open water, grassy uplands, and croplands that are intensively managed to provide feeding, resting, nesting, and brood rearing habitat for waterfowl and other water birds. Using a geographic information system to model roadless areas, only one roadless area is large enough for consideration as a WSA. This 7, 150 acre roadless area is crisscrossed with levees, which are large examples of man's alteration of the natural landscape.

Naturalness Criteria
Depending on water availability, seasonally flooded wetlands cover up to one-third of the Lower Klamath Refuge land area or approximately 15,000 acres. This habitat occupies the shallow peripheral areas of the original Lower Klamath Lake system. Seasonally flooded wetlands are characterized by a flooding regime extending less than year round, but greater than 6 months (of which 2 months must be during the growing season. While there may be areas at the Refuge offering solitude or naturalness, only one is larger than 5,000 acres and roadless. That roadless area consists of 7,150 acres, and is crisscrossed with levees, and is very noticeably influenced by man.

Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation
The 50,092-acre refuge is a varied mix of intensively managed shallow marshes, open water, grassy uplands, and croplands that provide feeding, resting, nesting, and brood-rearing habitat for waterfowl and other water birds. This refuge is one of the most biologically productive refuges within the Pacific Flyway. Approximately 80 percent of the flyway's migrating waterfowl pass through the Klamath Basin on both spring and fall migrations, with 50 percent using the Refuge.

Supplemental Values
The Refuge, with a backdrop of 14,000-foot Mount Shasta to the southwest, is listed in the National Register of Historic Places as a National Historic Landmark. However, Lower Klamath NWR does not meet the overall criteria for recommendation as a wilderness area because:

- Much of the roadless area has been bisected by levees;
- The roadless area is noticeably influenced by man.

As documented below, a roadless area within Clear Lake NWR meets the criteria necessary for a WSA.

Roadless Areas and Roadless Islands

Clear Lake National Wildlife Refuge in northeastern California consists of approximately 20,000 acres of open water surrounded by over 26,000 acres of upland bunchgrass, low sagebrush, and juniper habitat. Small, rocky islands in the lake provide nesting sites for American white pelicans, double-crested cormorants, and other colonial nesting birds. The lake has two lobes, an east and a western lobe with a "U" shaped peninsula between the two lobes.

Clear Lake NWR has mixed jurisdiction, with the Bureau of Reclamation having ownership over a large portion of the eastern lobe of the Lake, including primary jurisdiction over the "U" portion of the Refuge. Using a geographic information system to model roadless areas, only one roadless area with FWS primary jurisdiction is large enough for consideration as a WSA. This WSA consists of 9,882 acres of lands and open waters, primarily water, depending on the season.

Naturalness Criteria

Clear Lake was a natural lake that existed prior to construction of the Clear Lake Dam, which was constructed between 1908 and 1910 to increase the storage capacity of Clear Lake as part of the Klamath Project. The dam lies at the head of the Lost River, which flows northward from California into Oregon. A straight channel was cut between the two lobes of the lake in 1931 by Reclamation to augment the Klamath Project water supply during a drought in the early 1930's.

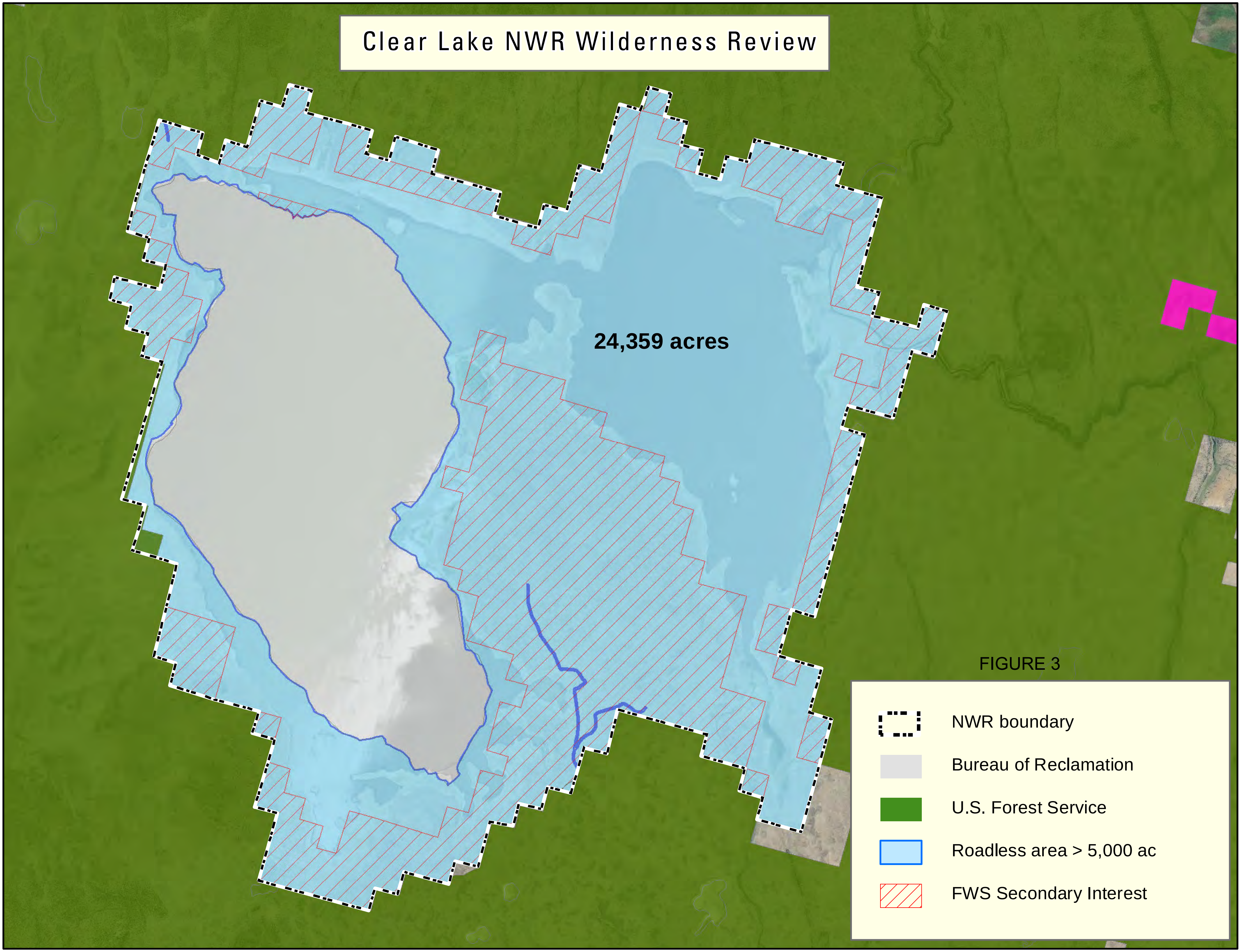
The upland areas provide habitat for pronghorn antelope, mule deer, and sage grouse. When the lake is low as it was in 2009 the amount of shoreline is greatly increased. Because the lake elevation fluctuates so much over time sagebrush cannot get established in the shoreline zone of the lake and invasive plants such as cheat grass and Medusahead tend to colonize those areas. Currently the shoreline vegetation consists primarily of forbs, perennial and annual grasses. Over the past 25 years, the lake elevation has fluctuated approximately twenty feet from 4,520 feet elevation in late summer of 1992 to 4,539 feet elevation in the spring of 1986. In the past five years the highest lake elevation reached was in the spring of 2006, when the lake was up to over 4,532 feet. The Clear Lake Reservoir is the primary source of water for the agricultural program of the eastern half of the Klamath Basin, with water levels regulated by the Bureau of Reclamation. Grazing has occurred regularly on the Refuge for decades. In recent years, approximately 5,500 acres (600 animal-unit-months [AUMs]) in the peninsula area ("U" Unit) of the Refuge have been grazed annually from mid-August to mid-November.

Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation

Except for limited waterfowl and pronghorn antelope hunting during the regular California State seasons, the refuge is closed to all public access to protect fragile habitats and to reduce disturbance to wildlife.

Supplemental Values

Some viewing of strutting sage grouse occurs in the spring from U.S. Forest Service Road 136, which runs along and through the refuge's southern boundary.


Clear Lake NWR Wilderness Review
24,359 acres
FIGURE 3
NWR boundary
Bureau of Reclamation
U.S. Forest Service
Roadless area > 5,000 ac
FWS Secondary Interest

Refuge unit	Yes/no and Comments					
	(1) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition;	(2) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable;	(3a) has outstanding opportunities for solitude;	or (3b) has outstanding opportunities for a primitive and unconfined type of recreation;	(5) contains ecological, geological or other features of scientific, educational, scenic, or historical value.	**Unit qualifies as a wilderness study area (meets criteria 1, 2, and 3a or 3b)**
Bear Valley	No, 2,494 ac.	No, numerous roads	Yes	Yes	Yes	No
Tule Lake	Yes, 9,346 ac.	Yes	Yes	Yes	Yes	Yes
Upper Klamath	Yes, 12,862 ac.	Yes	Yes	Yes	Yes	Yes
Lower Klamath	Yes, 7,150 ac.	No, crisscrossed with levees	Yes	Yes	Yes	No
Clear Lake	Yes, 9,882 ac.	Yes	Yes	Yes	Yes	Yes

Wilderness Study Areas within the Klamath Complex

Wilderness Study Areas

The three WSAs (Tule Lake, Upper Klamath, and Clear Lake NWRs) found to possess the required wilderness characteristics defined by the Wilderness Act were each further evaluated through the refuge planning process to determine their suitability for designation, management, and preservation as wilderness. Considerations in this evaluation included:

- Quality of wilderness values
- Evaluation of resource values, public uses, and associated management concerns; and
- Capability for management as wilderness or "manageability."

This information provides a basis to compare the impacts of a range of management alternatives and determine the most appropriate management direction for each WSA.

Quality of Wilderness Values

Tule Lake NWR WSA is entirely within Sump 1(A), which captures return irrigation flows from the Klamath Project. Tulelake Irrigation District operates most of the infrastructure on Tule Lake NWR under contract with the Bureau of Reclamation. This WSA is surrounded by 17,000 acres of agricultural lands.

Clear Lake NWR WSA consists of 9,882 acres adjacent to Bureau of Reclamation lands within the refuge. The Clear Lake Reservoir is the primary source of water for the agricultural program of the eastern half of the Klamath Basin, with water levels regulated by the Bureau of Reclamation. Grazing has occurred regularly on the Refuge for decades. In recent years, approximately 5,500 acres (600 animal-unit-months [AUMs]) in the peninsula area ("U" Unit) of the refuge have been grazed annually from mid-August to mid-November. The refuge is closed to the public except for waterfowl hunting on the shoreline, and pronghorn antelope hunting (six permits per year).

Upper Klamath NWR WSA consists of 12,862 acres, and is predominately marshlands and open water. Three boat launches are close to the perimeter of the WSA, allowing visitors to hunt, fish, and enjoy the solitude. The Service allows sport hunting for waterfowl, including geese, ducks (including mergansers), American coots (*Fulica americana*) and common moorhens (*Gallinula chloropus*), and Wilson's snipe (*Gallinago gallinago*) on designated areas of Upper Klamath NWR. Within the Refuge boundary on Upper Klamath Lake, recreational fishing is primarily done from boats. Two boat launches on the western shore of Upper Klamath Lake are the primary access points to the western portions of the Refuge.

Evaluation of Resource Values, Public Uses, and Associated Management Concerns

Tule Lake NWR WSA
Tule Lake WSA is entirely within Sump 1(A). Sumps 1(A) and 1(B) are managed under agreement among the Service, Reclamation, and the Tulelake Irrigation District. The sumps function to capture return flows during the spring/summer irrigation season, protect private property from flooding, and provide wildlife habitat. Most of the area is comprised of open water dominated by submergent plant communities with extensive periodic blooms of filamentous green algae. Minimum water levels in the sumps are mandated by a 1992 Biological Opinion to protect the endangered Lost River and shortnose sucker.

Motorized and non-motorized boats use the open waters of the refuge for hunting waterfowl. Currently, motorized boating is authorized within these 9,346 acres.

In cooperation with Ducks Unlimited, California Department of Fish and Game, Tule Lake Irrigation District, and the U.S. Bureau of Reclamation, the Service installed water control infrastructure in 1998 to allow for water level manipulation of Sump 1(B). During the early 2000s, a series of seasonal water drawdowns were conducted which allowed for the germination of emergent wetland plants and the enhancement of submergent plant communities. Prior to these management actions, the area had been flooded continuously for over 60 years. A similar project is currently in the planning stages for Sump 1(A)

Clear Lake NWR WSA
Clear Lake's water is managed by the Bureau of Reclamation; the left node of the lake is the Bureau of Reclamation's, and primary jurisdiction for the "U" is the Bureau of Reclamation, with secondary jurisdiction held by the Service. Over the past 25 years the lake elevation has fluctuated approximately twenty feet from 4,520 feet elevation in late summer of 1992 to 4,539 feet elevation in the spring of 1986. The 2002 Operations Plan for the Klamath Project issued a Biological Opinion (BO) for Clear Lake that lake levels are not to drop below 4520.6' between April 1 and September 30 to

protect two endangered fish; the Lost River and shortnose suckers. The uplands are used by pronghorn, mule deer, greater sage grouse (sage grouse) and other song birds.

Upper Klamath NWR WSA
Upper Klamath Refuge is almost exclusively composed of wetland habitat. The wetlands, however, are part of Upper Klamath Lake which is managed by the Bureau of Reclamation. Lake levels are currently controlled by a Biological Opinion which restricts the minimum lake level to 4139 feet or about one foot below the bottom of the marshes.

Upper Klamath Lake is hypereutrophic and regularly experiences massive blue-green algal blooms and water quality extremes (including high pH and ammonia concentrations, and widely variable dissolved oxygen concentrations) during the summer and fall. These degraded conditions are associated with unnaturally elevated inputs of nitrogen and phosphorus to the Lake, and seasonally high water temperatures. Water quality degradation in the Upper Klamath Lake watershed has led to large-scale fish kills related to algal bloom cycles in the lake. These episodes have also been correlated with seasonally high temperatures and low lake levels. Toxins generated by the algae are tied to fish die offs in the Lake, potentially including endangered suckers.

Capability for Management as Wilderness

Tule Lake NWR
Alternative A (Current Management)
Under this alternative, the Tule Lake WSA would not be recommended as suitable for wilderness designation. The following table illustrates the current Refuge management activities for the Tule Lake WSA.

Table A1. Wilderness Study Area Management Activities – Per Unit

Unit	Mgt Activity	Equipment/ Frequency/time of year
TL Sump 1(A)	Weed Treatments	The Service works to scout, map, and control priority weeds especially in priority wildlife habitats and uses an integrated pest management approach to control of invasive species. Practices employed include manipulation of water levels, tilling and disking, mowing, varying the timing of these practices, hand pulling of weeds, prescribed burning, bag-type repellents, trapping and removal, and application of pesticides. Trucks and All-Terrain Vehicles (ATV's) are driven on levees to open head gates. Pesticides are applied using hand wands or backpack sprayers; boomless sprayers mounted on ATV's, utility-terrain vehicles, or trucks; and occasionally from aircraft.
	Wetland Management	Wetlands are provided in Sump 1(A). USBOR maintain static water levels according to a 2008 BO. Motorized boats are used to apply prescribed fire of marsh in Sumps. The Service is planning on installing a water control structure to allow for water level manipulation of Sump 1(A) to allow for the germination of emergent wetland plants and the enhancement of submergent plant communities.
	Fire Treatments	From 1936 to 2005, there were 58 wildfires on Tule Lake Refuge. The agricultural uses on the Refuge have led to a high incidence of wildfire,

		often the result of escaped prescribed fires or vegetation debris burns. Until recently, lessees were permitted to burn their fields. Some of these burns escaped the intended fields, explaining a large percentage of wildfire activity on the Refuge. These types of wildfires have varied from only a few acres to over 3,000 acres. Air boats and specialty tracked vehicles and helicopters are used for prescribed fires in Sump 1(A). The high mountain desert climate combined with cured grasses and gusty winds have also been factors in a number of Tule Lake Refuge wildfires. The Refuge is bordered to its west by Sheepy Ridge. The ridge is covered in readily combustible fuels and has caught fire numerous times over the decades.
	Waterfowl Hunting	The Refuge is currently open for migratory game bird hunting (see Refuge-Specific Regulations for Hunting and Fishing, California at 50 C.F.R. §32.24). The Refuge offers a diversity of waterfowl hunting opportunities, including free-roam hunts in marshes using motorized and non-motorized boats (Sump 1(A), north of buoys) and in fields over harvested grain. Additionally, hunters may shoot from spaced blinds (numbered posts in dry fields), from Frey's Island, and from Sump 1B (east of buoys). A daily lottery is used to select individuals who are allowed to hunt in these latter three areas. An annual lottery is also used to select individuals to participate in waterfowl hunting on opening weekend. There are 6 boat launching and parking areas across the Refuge that provide access to the marshes [in sumps 1(A) and 1(B)].
	Guided Hunts	Typically, there are up to 5 hunting guides operating on the Refuge under Special Use Permits each hunt season. Guides must be qualified and licensed by the State of California and are required to submit in writing their experience, equipment and safety plans, which are evaluated by Service personnel during the competitive selection process. Waterfowl and pheasant are the target species. From between 2005 through 2014, guided recreational hunting for waterfowl on the Refuge averaged about 150 client use days per season, with a high of 250 use days in 2006 and a low of 120 use days in 2014. A majority of the permittees access the Refuge by privately owned vehicles then launch motorized or non-motorized boats on the flooded wetlands within the Refuge.
	Boating	There are 6 boat launching and parking areas across the Refuge that provide access to the marshes [in sumps 1(A) and 1(B)]. Boats may be used on all areas open to waterfowl hunting. All State boating requirements are enforced by refuge officers. Some boat-in areas are restricted to non-motorized boats only and these areas are open from sunrise to sunset. The non-motorized boating primarily occurs in two areas; the David Champine Canoe trail which is located in the eastern end of the second cell of Discovery Marsh. This trail is open year-round, subject to the available of water. A second

		canoe area is located in the northeast corner of Sump 1(A) where the Lost River channel enters the lake. This area is open between the end of the waterfowl nesting season and before the start of the hunting season (July 1st through Sept. 30).
	Current Water Management	Tule Lake Refuge wetland sumps receive their water from the Lost River and return flow irrigation. Water levels in the sumps have been stabilized to prevent flooding. The Tule Lake Tunnel (a concrete-lined 6,000-foot tunnel) was constructed to help in the water level stabilization by conveying drainage from the Tule Lake sump to the Lower Klamath Refuge. This transfer of water from Tule Lake to Lower Klamath Refuge has increased water volumes to the Lower Klamath Refuge wetlands. Management of water levels requires mechanized equipment to maintain and clear drains, ditches, and open gates. Vehicles are used to access areas, usually by driving on levees.
	Biological Surveys	Airboats, fixed-wing aircraft, and vehicles are used to survey waterfowl throughout the year, for monitoring, banding, and general access.
	Disease Monitoring	Since the 1940's when 100,000 birds died of botulism, waterfowl disease problems have occurred almost annually on Tule Lake and Lower Klamath Refuges; avian cholera and botulism type C cause the greatest mortality. Avian cholera was first recorded in 1955 and some winters have claimed up to 20,000 birds. Other chronic disease problems that occur each year but are not contagious and cause less mortality include lead poisoning, aspergillosis, and tuberculosis. Refuge staff use motor boats and air boats to survey for disease and collect dead birds.

Clear Lake NWR

Alternative A (Current Management)

Under this alternative, the Clear Lake WSA would not be recommended as suitable for wilderness designation. The following table illustrates the current Refuge management activities for the Clear Lake WSA.

Table A2. Wilderness Study Area Management Activities – Per Unit

Unit	Mgt Activity	Equipment/ Frequency/time of year
CL	Weed Treatments	Small amounts of the invasive annual grasses medusahead and cheatgrass are found primarily on the southwest corner and south side respectively of the Refuge. Trucks and ATVs are used to scout, map, and control priority weed species with an emphasis on protecting high priority wildlife habitat. In 2006, the Service obtained grant funding to remove encroaching juniper trees and in the fall over 1,400 acres of the Refuge was treated. The work was done by a contract crew with chainsaws and the trees were bucked up and left in place to provide wildlife cover.
	Fire Treatments	In an effort to increase the forb coverage and availability for deer, pronghorn and sage grouse, prescribed fires were conducted on the

		refuge in the 1990's. In 1993, one-hundred acres of low sage on the west side of the "U" were burned to stimulate production of forbs and grasses. In August, 1995 an additional 800 acres of low sage on the northwest side of the "U" was burned.
	Waterfowl Hunting	Sport hunting is permitted for waterfowl, including geese, ducks, American coots, common moorhens, and Wilson's snipe on designated areas of Clear Lake NWR. The hunt zone lies only along the shoreline of Clear Lake. The exact acreage varies due to the ever changing lake water level. The western shoreline is the only area open for waterfowl hunting, the remainder of the refuge is closed as sanctuary.
	Pronghorn Hunting	Pronghorn antelope hunting is by permit only and on a very limited basis. The California Department of Fish and Wildlife (CDFW) conduct a special drawing from successful tag holders of the Clear Lake Zone (zone 2). A maximum of 6 permits are allowed each year.
	Current Water Management	Clear Lake water levels are presently regulated for flood control and irrigation with minimum lake elevation dictated by the 2002 Biological Opinion. A minimum water level of 4,520.6 feet is mandated for October 1.
	Biological Surveys	Sage grouse monitoring is conducted using trucks and ATVs. Waterbird population sampling is generally performed using fixed-wing aircraft.

Upper Klamath NWR
Alternative A (Current Management)

Under this alternative, the Upper Klamath WSA would not be recommended as suitable for wilderness designation. The following table illustrates the current Refuge management activities for the Upper Klamath WSA.

Table A3. Wilderness Study Area Management Activities – Per Unit

Unit	Mgt Activity	Equipment/ Frequency/time of year
UK	Weed Treatments	Although pesticides have been approved for use, no acres have been treated with chemicals for invasive species control. For management purposes we reviewed and approved the potential use of pesticides on Upper Klamath NWR when we acquired the Barnes-Agency tract. Staffing constraints over the past several years have precluded conducting weed management with pesticides.
	Fire Treatments	Prescribed fire and fire suppression is accomplished using air boats, specialty tracked vehicles, and helicopters.
	Wetland Management	Hank's Marsh and Upper Klamath Marsh units of Upper Klamath Refuge are almost exclusively composed of freshwater marsh habitat. The wetlands are part of Upper Klamath Lake which is managed by the Bureau of Reclamation.
	Waterfowl Hunting	The Refuge is currently open for migratory game bird hunting (see Refuge-Specific Regulations for Hunting and Fishing, Oregon at 50 C.F.R. §32.56). The hunt zone totals almost 9,100 acres, including Hank's

		Marsh; and the northern, eastern, and southern portions of the emergent marsh in the NW corner of Upper Klamath Lake (see attached map). This total area comprises approximately 39% of the almost 23,100 acres under U.S. Fish and Wildlife Service (Service) management jurisdiction. The remainder of the Refuge is closed to migratory bird hunting and serves as a sanctuary area for waterfowl during the hunting season.
	Guided Hunts	There are expected to be up to 5 guides operating on the Refuge under Special Use Permits annually. Guides must be qualified and licensed by the State of Oregon. Commercially guided waterfowl hunting and fishing, including all means of access and other elements identified in the guides' operations plans. Authorized means of access for areas on the Refuge include motorized boats, non-motorized boats, hiking, snowshoeing, and cross-country skiing. Mechanized/electronic/motorized decoys and mechanized/electronic calls are authorized per state regulations.
	Boating	Waterfowl hunters primarily use boats to access the Refuge, with perhaps 75% launching from Rocky Point and a smaller number from Malone Springs. Both of these boat launches are on the western shore of Upper Klamath Lake, adjacent to the Refuge, and on the Winema National Forest. Motor boats are used by the public in all areas except the canoe trails. Motor boats are used throughout the Refuge by staff for administrative purposes. Within the Refuge boundary on Upper Klamath Lake, recreational fishing is primarily done from boats. Two boat launches on the western shore of Upper Klamath Lake are the primary access points to the western portions of the Refuge. Rocky Point and Malone Springs boat launches and their associated day-use areas are operated and maintained by the US Forest Service (USFS) and are open to public use free of charge. In 2014, the Refuge Manager estimated that 75% of the boaters on Upper Klamath Lake (including anglers) use the Rocky Point boat launch (paved boat ramp); the remaining 25% use the Malone Springs boat launch (shallow, gravel launch area).
	Biological Surveys	Periodic waterfowl surveys are flown from fixed-wing aircraft September through April ideally twice a month, but often only once a month and sometimes not at all depending on conditions.

Alternative B

Under this alternative, no units would be recommended for wilderness designation.

Tule Lake NWR

Tule Lake management of Sump 1(A) under Alternative B would require annual habitat objectives for proper waterfowl management as described in Appendices M and N, revise the Complex Fire Management Plan, and update the Inventory and Monitoring Plan.

Clear Lake NWR
Under Alternative B, management within the WSA of Clear Lake NWR would work with the Intermountain Research and Extension Station to develop control strategies targeted toward exotic annual grasses while protecting native grasses, shrubs, and forbs. Refuge staff will develop a rapid assessment and control program for new invasive species. Revise and renew the Complex Fire Management Plan, and revise the hunt plan to require non-toxic ammunition for the antelope hunt.

Upper Klamath NWR
Management of this WSA under Alternative B would include the development of an invasive species management program which includes monitoring. The Service also plans on preventing the introduction of aquatic invasive species by pursuing partnerships with the state of Oregon and USFS to develop and operate a portable decontamination station(s) near boat launches on Forest Service lands. Plans also include revising and renewing the Fire Management Plan, and updating the Refuge Inventory and Monitoring Plan. The Service also plans on marking the canoe trail with more signage to increase safety.

Alternative C

Under this Alternative, no units would be recommended for wilderness designation.

Tule Lake NWR
Management under this Alternative for the WSA in Sump 1(A) would be similar to Alternative B, except water elevation manipulation would be pursued to improve wetland diversity and productivity.

Clear Lake NWR
There is no Alternative C.

Upper Klamath NWR
There is no Alternative C.

Discussion

Each of the three WSAs is either in the water or on a marsh. Each WSA is also in an area where the control of the water is not with the Fish and Wildlife Service, but with the Bureau of Reclamation. Managing any of the WSAs as a wilderness may not be in the best interest of the Fish and Wildlife Service, due to lack of control over the water flow and levels.

Public Review and Comment

This Wilderness Study is an appendix to the CCP, and will be reviewed by the public, other government and non-governmental agencies, and interested groups. The comments provided on the CCP and appendices will help further develop and refine the alternatives presented and allow for better decision-making. A decision on the CCP and Wilderness recommendation will be made in the Final CCP.

The Refuge uses tracked cargo carrier such as the M548 as fire vehicles. The large wide tracks allow it to traverse relatively wet, muddy, and rough terrain that other heavy equipment cannot navigate. Each of the two M548s in the Refuge Complex are capable of hauling 400 to 600 gallons of water and are equipped with fire-fighting equipment including pumps, hose lays, and other tools.

Airboats are invaluable on the lakes and marshes, used for prescribed fire, survey and monitoring, and as a way to get out in the marshlands and open water quickly. In this photo, airboats were used to capture molting/flightless Canada geese in a funnel trap at Clear Lake for banding.

Appendix L – Best Management Practices

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Appendix L – Best Management Practices

Lower Klamath, Clear Lake, Tule Lake, Upper Klamath, and Bear Valley Refuges

Best Management Practices (BMPs) are designed to reduce adverse effects to wildlife and plants and their habitats on lands owned by the U.S. Fish and Wildlife Service. BMPs shall be implemented on Service-owned lands by all project coordinators.

<u>General BMPs</u>

1. All trash and construction debris shall be disposed of at disposal areas approved in writing by the U.S. Fish and Wildlife Service (Service).

2. Standard measures shall be implemented to minimize construction impacts on fish and wildlife, including avoiding unnecessary disturbance to habitats by driving on existing roads, working only in the required area, and minimizing direct disturbance to streams and open water sources.

3. All terms, conditions, and stipulations in regulatory permits and other project authorizations to eliminate or reduce adverse effects to endangered, threatened, and sensitive species and their critical habitats from actions described in the Comprehensive Conservation Plan (CCP), shall be adhered to.

4. Complete restoration activities at individual project sites in a timely manner to reduce disturbance and/or displacement of wildlife in the immediate project area.

5. Use existing roadways or travel paths for access to project sites.

6. Avoid the use of heavy equipment and techniques that will result in excessive soil disturbances or compaction of soils, especially on steep or unstable slopes, except as required for dike maintenance as approved by the Refuge Manager.

7. Streams, riparian zones, and wetlands shall not be used as staging or refueling areas. Equipment shall be stored, serviced, and fueled a minimum of 150 feet from aquatic habitats and other sensitive areas.

8. A written contingency plan shall be developed for all project sites where hazardous materials (e.g., pesticides, herbicides, petroleum products) will be used or stored. Appropriate materials/supplies (e.g., shovel, disposal containers, absorbent materials, first aid supplies, clean water) shall be available on site to clean up small scale accidental hazardous spill. Hazardous spills shall be reported. Emergency response, removal, transport, and disposal of hazardous materials shall be done in accordance with the U.S. Environmental Protection Agency. Hazardous materials and petroleum products shall be stored in approved containers or chemical sheds and be located at least 150 feet from surface water and in an area protected from runoff.

9. The evaluation of herbicide, pesticide, and fertilizer use shall include the accuracy of applications, effects on target and non-target species, and the potential impacts to aquatic and terrestrial ecosystems. Treatments for the control or removal of invasive plants in

riparian/wetland areas shall be limited to hand or wick applications by qualified personnel. Chemicals shall be applied during calm, dry weather and unsprayed buffer areas shall be maintained near aquatic habitats and other sensitive areas. Chemical applications are prohibited where seasonal precipitation or excess irrigation water is likely to wash residual toxic substances into waterways. All chemicals shall be handled in strict accordance with label specifications. Proper personal protection (e.g., gloves, masks, protective clothing) shall be used by all applicators. The material safety data sheet (MSDS) from the chemical manufacturer shall be readily available to the project coordinators for detailed information on each chemical to be used, in accordance with applicable Federal and State regulations concerning the use of chemicals. Chemicals shall only be considered when other treatments would be ineffective or cannot be applied.

10. Project coordinators shall ensure that all waste resulting from the completion of a project is removed and disposed of properly before work crews vacate the project site.

11. Structures containing concrete or wood preservatives shall be cured or dried a minimum of 36 hours before being placed in streams, riparian zones, or wetlands. No wet concrete or runoff from cleaning tools that have wet concrete slurry or lye dust shall enter aquatic habitats. Runoff control measures shall be employed, such as hay bales and silt fences, until the risk of aquatic contamination has ended.

12. Monitoring is required during restoration project implementation and for at least one year following project completion to ensure that restoration activities implemented at individual project sites are functioning as intended and do not create unintended consequences to fish, wildlife, and plant species and their critical habitats or adversely impact human health and safety. Corrective actions, as appropriate, shall be taken to address potential and existing adverse effects to fish, wildlife, and plants.

13. Prior to equipment use, special status plants and habitats shall be well-marked and communicated to equipment operators to avoid direct and indirect adverse effects.

14. An environmental awareness training program shall be presented to all construction personnel to brief them on the status of the special status species and the required avoidance measures.

15. To protect special status species, the Service will conduct the following activities:
(a) trails, roads, and/or areas will be closed to ensure that human access does not disturb special status species;
(b) prior to habitat and ground disturbing activities, potential habitat for special status species will be evaluated and, if appropriate, presence/absence surveys and additional mitigation measures taken (e.g., avoid location, change timing of action), if necessary, to ensure that planned activities do not disturb special status species; and
(c) the Service will comply with all terms and conditions resulting from section 7, Endangered Species Act consultation when specific projects are undertaken.

16. Bank stabilizing vegetation removed or altered because of restoration activities shall be replanted with native vegetation and protected from further disturbance until new growth is well established. Native shrubs, trees, and erosion control seed mixes from only local ecotypes shall be included in the reclamation and restoration of disturbed sites.

17. Sedimentation and erosion controls shall be implemented, when and where appropriate, during wetland restoration or creation activities to maintain the water quality of adjacent water sources.

18. Restoration activities that require prescribed burning shall be planned in coordination with the refuge manager and in accordance with the approved Fire Management Plan.

19. Slash materials shall be gathered by hand or with light machinery to reduce soil disturbances and compaction. Avoid accumulating or spreading slash in upland draws, depressions, intermittent streams, and springs. Slash control and disposal activities shall be conducted in a way that reduces the occurrence of debris in streams. These practices will eliminate or reduce debris torrents, avalanches, flows, and slides.

20. Snags shall be retained on project sites for cavity dependent wildlife species whenever possible.

21. Seedlings, cuttings, and other plant propagules for restoration shall be sourced from local ecotypes.

22. When necessary for invasive plant removal or habitat restoration, trees shall be felled away from streams, riparian zones, and wetlands whenever possible.

23. Livestock crossings and off-channel livestock watering facilities shall not be located in areas where compaction and/or damage may occur to sensitive soils, slopes, or vegetation due to congregating livestock. If livestock fords across streams are rocked to stabilize soils/slopes and prevent erosion, material and location shall be subject to the approval of the refuge manager.

24. Crushed rock is prohibited for use to stabilize fords. Fords shall be placed on bedrock or stable substrates whenever possible.

25. Implement the IPM approach and the best management practices required as part of the IPM Program (Appendix Q) to reduce potentially adverse effects to refuge resources.

26. Construction and habitat management activities shall be implemented during the non-breeding/nesting season for waterfowl to the extent feasible. Disturbance during the breeding/nesting season requires pre-construction surveys to locate active nests and establish buffers around the nest site until a wildlife biologist designated by the Service determines the nest site is abandoned. These and other mitigation measures shall be addressed in site-specific NEPA compliance once the locations of the project areas are identified. New facilities shall be sited in previously disturbed areas, to the extent feasible, and shall be designed to avoid sensitive habitats and affect the least amount of native vegetation.

27. Prior to construction and ground-disturbing activities, project sites and staging areas shall receive pre-watering and other preparations maintaining surface soils in stabilized conditions where support vehicles and equipment will operate.

28. During ground-disturbing activities including clearing, grubbing and earth moving activities, water or an approved dust palliative shall be applied to keep soils moist throughout the process and immediately after completion.

29. Sloping surfaces equal to or steeper than 10% shall be stabilized using soil binders approved in writing by the Service until vegetation can effectively stabilize the slope.
30. Stipulations defined in the Compatibility Determinations shall be implemented in the course of refuge management activities and for refuge use activities conducted under special use permits.

<u>Haying</u>

31. Haying activities shall be timed to minimize adverse effects to wildlife. In accordance with the Pacific Flyway Management Plan for the Central Valley Population of Greater Sandhill Cranes (Pacific Flyway Council 1997), haying shall be delayed until after July 15 to prevent the mowing mortality of young sandhill cranes. The Service may also delay the start of haying if sandhill crane colts less than three weeks of age are present.

32. Haying in areas where Greater Sandhill Cranes do not occur shall be delayed until after August 1 each year to minimize adverse effects to other ground nesting birds. After August 1, haying shall be conducted as quickly as possible to benefit migrating birds and ensure that fields can be re-flooded and green-up can occur prior to the peak migration period in October.

33. Standard construction BMPs shall be implemented to prevent invasive plants from establishing during ground-disturbing activities including: prior to accessing the refuge, vehicles and equipment shall be cleaned off-site with high-pressure sprayers to dislodge seeds.

34. Flushing bars are required on all hay cutting equipment when used prior to July 15.

35. Field work is not authorized during April15 through May 31 of each year.

36. Waterfowl shall not be herded or harassed from January 1 to April 30.

<u>Pesticide Application and Integrated Pest Management</u>

37. To protect the health of workers, pesticide applicators shall wear appropriate personal protective gear (e.g., clothing, gloves, and masks) in accordance with state applicators' licensing requirements when applying, mixing, or otherwise handling pesticides on the refuge. Detailed, refuge- and site-specific BMPs are included and implemented through the Service's Pesticide Use Proposal process to protect refuge resources. BMPs for mixing, handling, and applying pesticides for all ground-based pesticide treatments are specified in the IPM Program (Appendix Q).

<u>Water/Riparian</u>

38. Ground-disturbing activities shall incorporate the use of sediment barriers or other erosion control devices downstream of the activities.

39. Ground-disturbing activities, vehicles, and machinery are prohibited in water bodies and prohibited within a 150-feet buffer zone surrounding water bodies.

40. Stream crossings will be limited to designated and existing locations.

Air and Noise

41. Operation of equipment, machinery, and large vehicles is restricted to daylight hours, between the hours of 8:00 a.m. and 5:00 p.m. unless otherwise specified in writing within the construction contract, special use permit, or by the refuge manager.

42. When hauling operations are being conducted, unpaved access routes shall be wetted each day by the contractor to reduce fugitive dust.

43. To reduce dust, effective cover shall be maintained by the contractor over stockpiled fill or debris materials.

44. Vehicle speeds shall be limited to 15 miles per hour or less in staging areas and on all unpaved access routes; and to 25 miles per hour on paved refuge access roads.

45. Applicable recommendations from the local air quality district shall be implemented to minimize vehicle and equipment emissions during construction and habitat management activities.

Hunt-related

46. During movement of hunting blinds and other portable structures, measures shall be taken to minimize generation of dust and erosion associated with these small construction projects. Measures may include the use of watering trucks and erosion-control barriers to mitigate adverse effects.

47. Except for spot maintenance to remove obstructions, no improvements shall be made to intermittent waterways and no clearing shall be done in forested areas.

Fire Management

48. Prescribed burning plans will be developed; a burning permit will be obtained from the Air Pollution Control District and adhered to; activities will be coordinated with the Air Pollution Control District.

49. The fire management program at Klamath Basin Refuges will comply with the Air Quality Smoke Management Guidelines presented in the Service's Fire Management Handbook.

50. To reduce the likelihood that prescribed burns would generate substantial volumes of smoke that would drift into populated areas of the Klamath Basin, the Service will continue on-going training of fire personnel and site-specific planning prior to ignition in accordance with the refuge's Fire Management Plan.

51. Small unit sizes, wind direction, and distance to receptors will be considered to mitigate adverse effects of prescribed burns.

52. Fire lines shall be located outside of highly erosive areas, steep slopes, intermittent streams, riparian areas, and other sensitive areas.

53. The use of fire retardants and foams are prohibited in riparian areas.

54. At Bear Valley NWR, mechanical thinning (large equipment) are prohibited within 100 feet of intermittent streams and steep slopes (>35% slope);

55. At Bear Valley NWR, mechanical equipment shall be restricted in operations to dry or frozen ground (<20% soil moisture).

56. At Bear Valley NWR, thinning and prescribed fire operations will be concentrated between August 1 and November 15 to avoid potential impacts to nesting and/or roosting bald eagles.

57. During the peak bald eagle roosting period (November 15-April 1), Service personnel may enter the refuge to conduct habitat management (treatment unit) reconnaissance and layout; however, this activity shall only occur in the refuge during the daylight hours when the eagles are not present (approximately between 9:00 a.m. and 3:00 p.m.).

58. During the bald eagle nesting season (April 1 through July 31), prescribed fire will be allowed on some stands in the spring months and thinning efforts will be allowed on some stands during the spring and summer months after consultation with and clearance from an endangered species biologist(s) designated by the Service, and only after meeting the following mitigation measures:
    (a) work shall be prohibited within ½-mile from active nests;
    (b) an wildlife observer may be stationed to watch active nests for any disturbance caused by smoke or noise from thinning and prescribed fire activities (on Pearson Butte at Bear Valley NWR);
    (c) work shall be immediately curtailed in the event that disturbance was observed;
    (d) backing fires shall be used when possible to limit smoke production. All burns shall be aggressively mopped-up (managed until out); and
    (e) burn prescriptions shall be written to minimize the potential for high-intensity fire and to avoid severe drought and/or high wind conditions.

59. All sites where improvements are made or obstructions removed will be rehabilitated to pre-fire conditions, to the extent practicable.

60. Whenever consistent with safe, effective suppression techniques, the use of natural barriers will be used as extensively as possible.

61. Following the conclusion of fuels thinning activities, road improvements shall be made, as necessary, to repair damage to the access roads resulting from vehicle and equipment use associated with thinning operations.

Fire Management - Cultural Resources

62. Prior to all thinning and prescribed fire activities, cultural resources in treatments areas will be identified and avoided.

63. If unrecorded cultural resources are discovered during thinning and prescribed fire activities, all work in the immediate vicinity of the cultural resource will stop until an archeologist designated by the Service surveys and records the location, and issues a written notice allowing work to resume.

64. Continued training of fire personnel and careful planning prior to ignition would continue to reduce the likelihood that prescribed burns on the refuge lands would escape and become wildfires.

65. No handlines exposing mineral soil will be allowed through cultural sites, and all handlines will be revegetated with an endemic native erosion control seed mix. Erosion control methods will be used on slopes exceeding 30% where handline construction takes place.

Cultural Resources

66. Potentially adverse effects to cultural resources shall be minimized through cultural resource reviews, surveys, and compliance with section 106 of the National Historic Preservation Act (NHPA). All sites discovered in the future shall be treated as eligible for listing on the National Register of Historic Places (NRHP) until listed or formally evaluated as ineligible in consultation with the State Historic Preservation Officer (SHPO).

67. Under federal ownership, archaeological and historical resources within a refuge receive protection under federal laws mandating the management of cultural resources, including, but not limited to, Archaeological Resources Protection Act (ARPA), AHPA, Native American Graves Protection and Repatriation Act of 1990 (NAGPRA), and National Historic Preservation Act (NHPA). Should any cultural resources be discovered on the refuges, ground-disturbing activities shall be stopped immediately and not resumed until authorized in writing by the Service to do so. The Service will take all necessary steps to comply with section 106 of the NHPA, in consultation with the SHPO and pertinent tribes.

68. Sites identified in the future could be found to contain human remains, funerary items, sacred objects, or items of cultural patrimony and may therefore require consideration under the NAGPRA). The Service will comply with the NAGPRA consultation process and other applicable laws and guidance required for consideration of human remains.

69. Under federal ownership, paleontological resources within a refuge receive protection under federal laws mandating the management of paleontological resources, including, but not limited to, Paleontological Resources Preservation Act (Public Law 111-011) (Omnibus Public Land Management Act of 2009). Collection of paleontological resources is prohibited on the Refuges. Under the provisions of the Act, the Service may restrict access or close areas to further protect paleontological resources or for public safety.

Public Use

70. Areas under construction or being restored would be temporarily closed to public use for public safety. These areas will be adequately marked and information on other recreational areas will be provided to the public.

71. Construction will be scheduled during the week or during slower seasons when feasible, to minimize the impacts of construction traffic on public access.

References Cited

Pacific Flyway Council. 1997. Pacific Flyway management plan for the Central Valley Population of Greater Sandhill Cranes, Pacific Flyway Study Comm. [c/o Pacific Flyway Representative USFWS], Portland, OR 97232-4181. Unpubl. Rept. 44pp. + appendices.

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Appendix M – The Kuchel Act and Management of Lower Klamath and Tule Lake National Wildlife Refuges

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The Kuchel Act and Management of Lower Klamath and Tule Lake National Wildlife Refuges

U.S. Fish and Wildlife Service
Klamath Basin National Wildlife Refuges
Tulelake, California

April 17, 2015

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Special appreciation is extended to Mark Petrie with Ducks Unlimited and Bruce Dugger at Oregon State University for assessing the carrying capacity of refuge habitats for waterfowl and subsequent bioenergetics modeling. Fred Pavaglio, Kevin Kilbride, and Steve Moore with the U.S. Fish and Wildlife Service's Region 1 Office facilitated and provided materials for the initial workshop in September of 2002. Other individuals who provided input and suggestions during one or both workshops and/or document review included Brad Bales, Marty St. Louis, Tom Collom, and Lanny Fusishan (Oregon Department of Fish and Wildlife); Bob Smith, Shaun Oldenburger, Dan Yparriegurrie, Tim Burton, and Richard Shinn (California Department of Fish and Wildlife); Gary Ivey (International Crane Foundation); Dave Shuford (Point Reyes Bird Observatory); Joe Fleskes (U.S. Geological Survey); John Alexander (Klamath Bird Observatory); Bruce Dugger (Oregon State University); Robert Frederick (Eastern Kentucky University); Tim Griffiths and Mark Sveniawski (Natural Resource Conservation Service); Greg Yarris (California Waterfowl Association); Mike Green (U.S. Bureau of Reclamation), Tim Mayer, Phil Norton, Jim Hainline, Greg Mensik, Sallie Hejl, Mike Wolder, and Bob Trost (U.S. Fish and Wildlife Service); and Mark Petrie and Mike Shannon (Ducks Unlimited). Special thanks are extended to Steve Moore (Bigfoot Consulting and retired U.S. Fish and Wildlife Service, Chief of Refuge Operations, Region 1) for his review of the legislative history and policy sections of this document.

Executive Summary

The Klamath Reclamation Project (Project), initiated in 1905, sought to drain the historic lakes and marshes of the Upper Klamath Basin for the purpose of creating dry land suitable for agricultural development. In the midst of Project development, Lower Klamath and Tule Lake National Wildlife Refuges (NWRs) were established by Executive orders in 1908 and 1928, respectively; however, these lands retained their prior withdrawal for reclamation purposes. Thus was born the conflicting expectations for land management within the Klamath Project. As the lakes and marshes within the Project were drained, lands were passed to private ownership through the homesteading process, ultimately leading, in the 1950s, to proposals to homestead portions of Tule Lake and Lower Klamath NWRs. After nearly a decade of debate, the Kuchel Act (Public Law 88-567, 16 U.S.C. 695k-r) was enacted in 1964. The legislation dedicated the lands within the boundaries of Tule Lake and Lower Klamath NWRs to wildlife conservation for the major purpose of waterfowl management and placed the lands permanently in ownership by the United States. Agricultural leasing that is consistent with proper waterfowl management would continue. The mandate of continuing an agricultural leasing program consistent with "proper waterfowl management" on two national wildlife refuges complicates traditional refuge management. Various persons or entities interpret some portions of the Kuchel Act differently.

In 1997, Congress amended the National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd-668ee) with passage of the National Wildlife Refuge System Improvement Act (Pub. L. 105-57). This Act requires the development of comprehensive conservation plans (CCPs) for each refuge in the National Wildlife Refuge System (NWR System). These CCPs are to guide refuge management for a 15-year period. Refuge CCPs are to consider the mission and policies of the Refuge System; however, the establishing EO's and legislated refuge purposes, such as the Kuchel Act take precedence. During the CCP process, the U.S. Fish and Wildlife Service (Service) is required to evaluate all aspects of refuge management and prepare alternatives for evaluation and public review. Prior to developing alternatives, the Service needs to articulate its interpretation of the Kuchel Act in a manner consistent with the Act's language and Congress' intent, and determine how implementation of the Kuchel Act will be integrated with mandates from the 1997 Improvement Act. Proper interpretation of legal mandates guiding refuge management is key to developing management alternatives during the CCP process as well as a framework from which to conduct future management planning.

This document is divided into nine chapters. Chapter I introduces the reader to a summarized history of Lower Klamath and Tule Lake NWRs, including their relationship to the Klamath Reclamation Project. Chapter II describes the legal directives pertinent to the refuges with an emphasis on refuge purposes derived from the Kuchel Act. In reviewing language in the Kuchel Act and congressional testimony, it is clear that the intent of the Act was to provide for proper waterfowl management as the major purpose of the refuges and if consistent with proper waterfowl management to continue the refuge leased land farming program in specific areas of the refuges to benefit the waterfowl resource as well as adjacent counties and the local farm economy. Other areas of the refuges were also to be managed for the primary purpose of waterfowl management, but with greater flexibility in management, and to serve a wider array of wildlife values.

Chapters III, IV, and V define key terms within the Kuchel Act, including those terms related to wildlife conservation (with an emphasis on "proper waterfowl management") and those terms related to agriculture. Most importantly, these chapters also describe how the Service interprets and prioritizes these terms and integrates them with other Refuge System legal mandates and policies. In terms of the refuge leased land program, the Service will integrate the program into the overall habitat management planning process such that these lands serve a designated function in meeting refuge-wide wildlife population objectives, with an emphasis on migratory waterfowl. Refuge leased land contracts will be structured to achieve this function.

Chapters VI, VII, and VIII... Chapter VI provides a historical context for how waterfowl use of both refuges have responded to habitat management programs under the Kuchel Act. This comparison of waterfowl use between the 1970s and 1990s indicates that Tule Lake NWR, in particular, has experienced significant declines in some waterfowl guilds. Chapter VII introduces new migratory waterfowl population objectives and, using a bioenergetics model, assesses the ability of current habitat management programs to support these objectives. This analysis indicates that shortages in foraging resources for waterfowl are evident on both refuges, and especially on Tule Lake NWR. Chapter VIII provides a document summary and a series of recommendations for future refuge management.

Chapter I Introduction

"We cruised over a large part of the lake, and found that the large rookeries of cormorants, grebes, white pelicans, great blue herons, California gulls and Caspian terns form one of the most extensive bird colonies we have ever seen. Doubtless this locality has never been disturbed to any extent by Man. This is the great breeding ground of that whole region."

(William Finley at Lower Klamath Lake, 1905)

Breakfast in the tules. Bohlman in the boat, Finley on the box.

The Klamath Basin of northern California and southern Oregon historically contained over 350,000 acres of wetlands (Akins 1970) with Tule Lake and Lower Klamath Lake being two of the largest lake and marsh habitats (Fig. 1). According to the summary presented in Weddell et al. (1998) and writings by early 19th century naturalist William Finley, wildlife populations were extensive. However, despite the presence of these significant wildlife resources in the historic lakes and marshes, the potential for agricultural development was soon realized and pursued by early Euro-American settlers to the area.

Lower Klamath and Tule Lakes were originally acquired from the United States by Oregon and California under the Swamp and Overflowed Lands Act of 1850 (9 Stat. 519, September 28, 1850, 43 U.S. C. 971-994). Privately financed irrigation in the Klamath Basin began in 1882; by 1903, it had expanded to over 10,000 acres (Weddell et al. 1998). In 1902, the Reclamation Act (Public Law 57-161, 43 U.S.C. 391 et seq.) was passed, which authorized the establishment of Federal irrigation projects across the arid and semi-arid West. In 1905, California and Oregon passed legislation ceding the lands underlying Tule and Lower Klamath Lakes back to the United States for reclamation purposes, and the United States then withdrew these lands from entry by private individuals. Prior to this withdrawal, about 20,000 acres of Lower Klamath Lake marshes had been patented to individuals (Weddell et al. 1998). In May of 1905, the Klamath

Reclamation Project (Project) was authorized; by 1907, the first irrigation deliveries through Project facilities began. The first announcement opening reclaimed lands to homesteading was made in 1908.

One of the principal activities of the Project was to lower the levels of Tule and Lower Klamath Lakes. For Tule Lake, this was accomplished by withholding and diverting the Lost River from reaching its historic destination in Tule Lake. Lower Klamath Lake was reduced in size by severing its connection to the Klamath River. With the shutoff of water to Tule and Lower Klamath Lakes, the lake beds became exposed and dried, allowing their use for farming. From 1922 to 1948, most of the exposed Tule Lake bed passed to private ownership through the homesteading process (Abney 1964).

Lower Klamath and Tule Lake National Wildlife Refuges (NWRs) were established after initiation of the Project. Both refuges are within the Project (Fig. 1) and exist on lands that were previously withdrawn for reclamation purposes. The Federal Executive Orders that established these refuges provided that the lands retained prior withdrawal for reclamation purposes. Lower Klamath NWR was established on August 8, 1908, by Executive Order (EO) 924, "…as a preserve and breeding ground for native birds." Lower Klamath NWR was established primarily to protect waterfowl and colonial nesting waterbirds from the market hunting that occurred early in the 20th century.

In the midst of Project development, Tule Lake NWR was established by EO 4975 on October 4, 1928, "…as a refuge and breeding ground for birds." Biologically, the refuge was established for several reasons. First, it was necessary to control the high level of essentially unregulated waterfowl hunting that was occurring. Second, it was believed that establishing a refuge on Tule Lake would help offset the loss of habitat and birds occurring at that time on Lower Klamath Lake. A more extensive discussion of refuge establishment (both Tule Lake and Lower Klamath NWRs) can be found in Weddell et al. (1998). Refuge purposes for both Lower Klamath and Tule Lake NWR were further refined with passage of the Kuchel Act in 1964 (16 U.S.C. 695k-r).

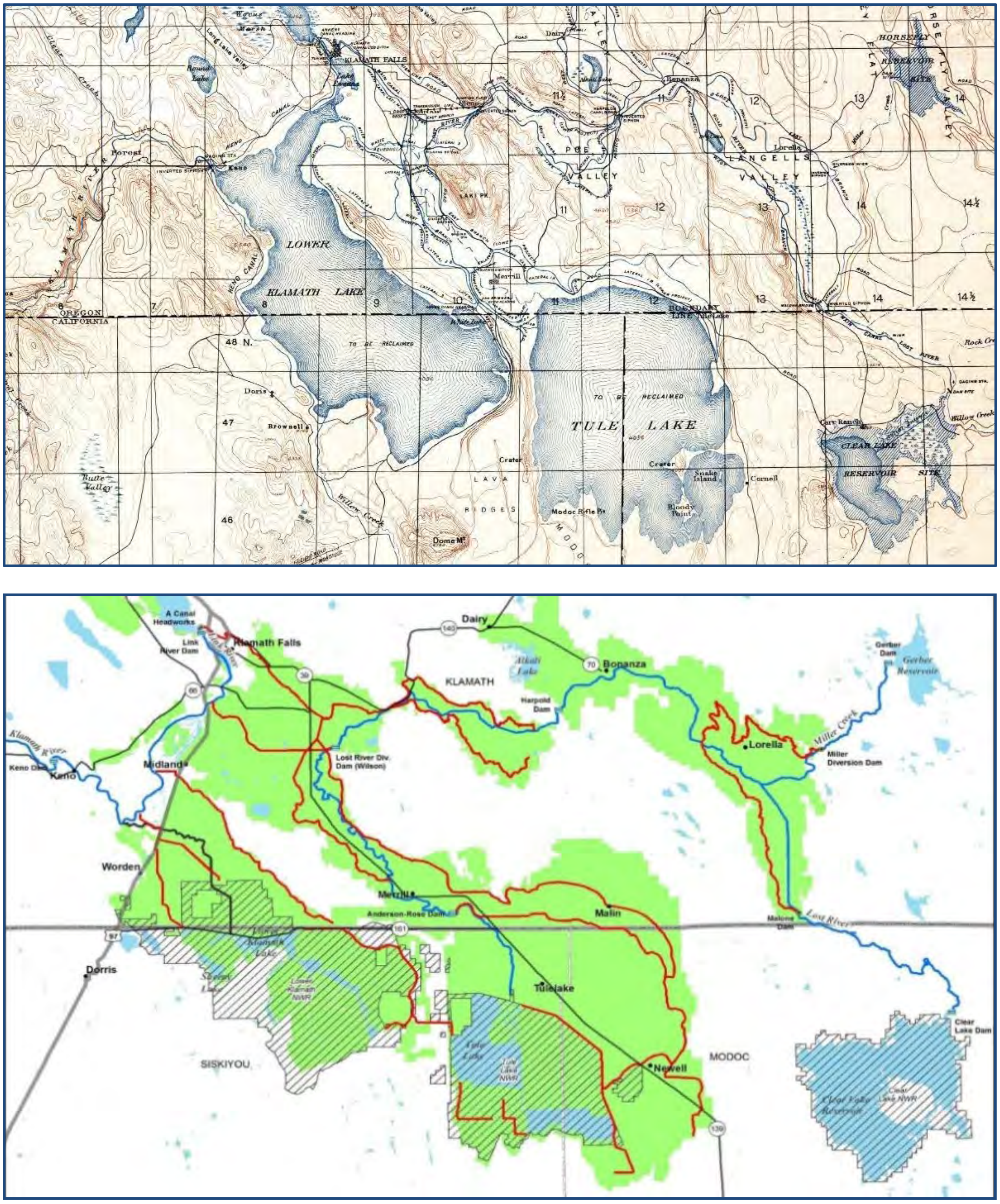

Fig. 1 Lower Klamath and Tule Lakes prior to Project development (circa 1905) (top) and current location of Tule Lake and Lower Klamath National Wildlife Refuges (cross-hatched) within the Klamath Reclamation Project (in green) (bottom).

Rationale for document

Interpretation of the Kuchel Act has become increasingly controversial. Some environmental conservationists believe that the size and scope of current agricultural programs on these refuges is inconsistent with the mission of the National Wildlife Refuge System (NWR System, Refuge System), and some with agricultural interests believe that the Kuchel Act guarantees that the agricultural program will continue unchanged from its present configuration. At the heart of the controversy is the largest commercial farming program in the Refuge System. Currently a 22,000-acre agricultural leasing program operates on Tule Lake and Lower Klamath NWRs. The program consists of more than 200 lots that are leased to local growers by a sealed bidding process. Successful bidders have the annual option to renew for up to five years. In 2012, gross lease revenues exceeded $4.4 million. The leased agricultural lands represent a portion of the overall habitat complex on Tule Lake and Lower Klamath NWRs. As such, they require integration and/or modification, subject to the Kuchel Act, such that the overall habitat management program fulfills refuge wildlife and—more specifically—waterfowl objectives.

The National Wildlife Refuge System Administration Act (Administration Act) of 1966 (16 U.S.C. 668dd-668ee), as amended in 1976 (Public Law 94-233), designated the U.S. Fish and Wildlife Service (Service) as the agency responsible for administering units of the Refuge System, including Kuchel Act lands. Currently, the U.S. Bureau of Reclamation (Reclamation) administers the agricultural leasing program on the refuges on behalf of the Service under a 1977 cooperative agreement between the agencies.

In 1997, Congress amended the Refuge System's 1966 Act with passage of the National Wildlife Refuge System Improvement Act (Improvement Act) of 1997 (Pub. L. 105-57). This Act requires the development of comprehensive conservation plans (CCPs) for each refuge in the NWR System. These CCPs are to guide refuge management for a 15-year period. Refuge CCPs are to consider the mission and policies of the NWR System; however, where legislated purposes, such as the Kuchel Act, conflict with the NWR System mission, legislated purposes take precedence. During the CCP process, the Service is required to evaluate all aspects of refuge management and prepare alternatives for evaluation and public review. However, prior to developing alternatives, the Service needs to articulate its interpretation of the Kuchel Act in a manner consistent with the Act's language and Congress' intent.

The purpose of this document is to (1) establish refuge purposes for Lower Klamath and Tule Lake NWRs, (2) determine the intent of the Kuchel Act, particularly relative to leased land farming, (3) define key terms, including those related to wildlife conservation (with an emphasis on waterfowl management) and those related to agriculture, (4) evaluate waterfowl populations trends on the refuges since passage of the Kuchel Act, (5) evaluate current habitat management programs relative to waterfowl population objectives, and (6) recommend appropriate changes using a bioenergetics approach for conservation planning, consistent with the Kuchel Act, for waterfowl habitat management programs on Tule Lake and Lower Klamath NWRs. Overall, this document will provide a framework for developing and evaluating alternatives in the CCP planning process and for developing specific habitat management plans and compatibility determinations in the future.

Chapter II Legislative history and refuge purposes

Introduction

Refuge management priorities derive from the Refuge System mission; individual refuge purpose(s); laws that specify Service responsibilities for trust resources; the mandate to maintain the biological integrity, diversity, and environmental health of the public's refuges; and relevant Executive orders, regulations, and policies. The following narrative discusses the origin of refuge purposes, their role in refuge management, and the methods by which those purposes are prioritized or reconciled where conflicts exist.

The Refuge System Improvement Act established a legislative mission for the NWR System: "*The mission of the System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans*." Additionally the Improvement Act directed the Secretary of the U.S. Department of Interior (Interior) to "…*ensure that the biological integrity, diversity, and environmental health of the System are maintained*…" The Improvement Act defined refuge purposes as the "*purposes specified in or derived from the law, proclamation, executive order, agreement, public land order, donation document, or administrative memorandum establishing, authorizing, or expanding a refuge, refuge unit, or refuge subunit*."

Collectively, the Refuge System mission and refuge purpose(s) define the duty of the Service in the administration and management of any refuge in the Refuge System. Ideally, the Refuge System mission and refuge purpose(s) are symbiotic in nature. Refuge purposes that deal with conservation, management, and restoration of fish, wildlife, and plants and ecosystem health take precedence over other purposes in the management and administration of a refuge, "***unless otherwise indicated in the establishing law, order, or other legal document***" [emphasis added] (601 FW 1.15). Therefore, although the Improvement Act established a mission for the Refuge System and directed the Secretary to maintain the System's biological integrity, diversity, and environmental health, these purposes do not supersede the specific purposes of the Lower Klamath and Tule Lake NWRs provided in their establishing Executive orders or specific provisions of legislation such as the Kuchel Act (Public Law 88-567, 16 U.S.C. 695K-r).

Establishing Executive orders

Refuge purposes were originally established for Lower Klamath NWR by EO 924 on August 8, 1908. This EO was subsequently amended by EO No. 2200 (May 14, 1915), No. 3187 (December 2, 1919), No. 3422 (March 28, 1921), and No. 8475 (July 10, 1940). These later EOs changed the name and size of the refuge. From the EOs, refuge purposes for Lower Klamath NWR include:

1. "…as a preserve and breeding ground for native birds." (EO 924), and

2. "…protection of native birds." (EO 2200)

Initial refuge purposes for Tule Lake NWR were established by EO 4975 on October 4, 1928. This EO was subsequently amended by EO 5945 (November 3, 1932) and EO 7341 (April 10, 1936), which changed the name and size of the refuge. The EOs provided the following purposes for the refuge:

1. "…as a refuge and breeding ground for birds…" (EO 4975), and

2. "…as a refuge and breeding ground for wild birds and animals" (EO 5945).

The Executive orders establishing these refuges also provided that the lands retained prior withdrawal for reclamation purposes, addressed later in the Kuchel Act.

Kuchel Act (Public Law 88-567, 16 U.S.C. 695k-r) (Appendix 1)

Because the lands within the boundaries of both Tule Lake and Lower Klamath NWRs were subject to prior reclamation purposes, they were ultimately vulnerable to the homesteading process. Thus, in the 1950s, Reclamation proposed homesteading and transferring areas of the refuges into private ownership. This proposal resulted in intense debate between agricultural interests and conservationists over the future of the refuges at a time when Tule Lake and Lower Klamath NWRs held fall waterfowl populations that were unparalleled in North America, with peak populations exceeding 5-7 million birds during fall migration.

Several individuals noted these waterfowl concentrations. Refuge manager C. Fairchild (Fairchild et al. 1939) wrote: *"…considerable grain is left on the ground to provide an abundance of food for migratory waterfowl. This happy combination of suitable water area closely and completely surrounded by abundant food and situated in the middle of the Pacific Flyway attracts enormous numbers of both ducks and geese to this refuge on their migrational flights .... The Tule Lake Wildlife Refuge is classed as one of the primary refuges in the entire United States. Judged solely from the number of birds utilizing the refuge, the area involved, and the available food, it is without question the most important refuge on the Pacific Flyway."*

Service Director John Farley, in a transmittal letter (U. S. Fish and Wildlife Service 1956a) with the Service's 1956 report "Plan for wildlife use of federal lands in the Upper Klamath Basin" (U.S. Fish and Wildlife Service 1956b), stated: *"Adequate lands, water, and food for waterfowl in the Upper Klamath River Basin are indispensable to the welfare of the Continental waterfowl population. About 80% of all the waterfowl of the Pacific Flyway funnel through the Upper Klamath River Basin in their annual migrations. In the Fall of 1955, for example, there were at one time upwards of 7,000,000 birds on the Lower Klamath and Tule Lake National Wildlife Refuges in the Basin. This is the greatest concentration of waterfowl in North America and probably in the world."*

To address the controversy associated with potential homesteading and refuge land transfers, the Secretary of the U.S. Department of the Interior directed Reclamation and the Service to conduct studies and submit recommendations. In response, Reclamation submitted its report (U.S. Bureau of Reclamation 1954) followed by the Service report (U.S. Fish and Wildlife Service 1956b). For the most part, these studies represented opposing viewpoints. To reconcile these differences, the Secretary assigned a technical review staff to evaluate the available information. The review staff's report recommended that refuge lands not be homesteaded and that the lands be permanently retained under a leasing system. It was believed that administratively maintaining the leasing program would not settle the controversy as the issue would continue to surface with new administrations. Thus, the report recommended that the leasing system be permanently maintained through legislative action. Among other recommendations, the report also recommended that lease revenues be shared with the counties and that legislation be proposed for additional actions that could not be taken administratively (Bennett 1958).

Based on this report, on April 1, 1958, Secretary Fred Seaton approved a plan to settle the controversy stating that Tule Lake and Lower Klamath NWRs: *"…must be used in a manner that will fully protect the valuable waterfowl resources of that area…"* The plan sought to halt homesteading within the refuges but would allow for continued agricultural leasing of refuge lands. "*The Fish and Wildlife Service and game agencies of California and Oregon declare that retention of the present leasing system is essential to maintain the wildfowl population of the Pacific Flyway without danger of extensive crop depredation, unless or until substitute wildfowl habitat along the Flyway has been provided*." (U.S. Department of the Interior 1958).

Weddell et al. (1998) summarized the legislative progress of the proposed legislation: "*Initially the Kuchel Act was introduced as Senate bill S. 1988 in 1962. A hearing was held on February 23, 1962, by the Subcommittee on Irrigation and Reclamation of the Committee on Interior and Insular Affairs. The bill passed the Senate without opposition, but time did not permit the House to finish consideration (Hearing before the Subcommittee on Irrigation and Reclamation, February 23, 1962).*

The following year Senator Engle sponsored S. 784 and Congressman Johnson introduced a similar bill in the House of Representatives. In addition, Senator Kuchel and Senator Robertson introduced S. 793. In most respects the two bills were similar. A hearing on S. 784 and S. 793 was held on April 24, 1963. S. 793 ultimately became Public Law 88-567 on September 2, 1964 (Hearing before the Subcommittee on Irrigation and Reclamation, April 24, 1963."

The essence of the debate over the Kuchel Act was summarized in Secretary Stewart Udall's statement before the Senate's Interior and Insular Affairs Committee (Udall 1962). Secretary Udall believed that the proposed Kuchel Act (S. 1988) would settle the long-standing question on the ultimate fate of refuge lands. He recognized that local interests desired that the lands remain in agricultural use and be transferred into private ownership; however, he also acknowledged the opposing view from the conservation community and farming interests further south in California, who wanted the refuge's waterfowl values be preserved. He also knew the Department of Interior had obligations to both the Project and the migratory waterfowl resource through international treaty responsibilities and that the bill was in the greater public interest. Thus, the Secretary supported the bill, as it would both retain refuge lands in Federal ownership with the major purpose of waterfowl management and would still maintain agricultural leasing consistent with the irrigation purposes of Klamath Project and the economic needs of local communities. In congressional hearings, representatives from both the Bureau of Reclamation and the Fish and Wildlife Service were united in their support for the legislation.

At the time, the bill was viewed as a win-win solution. The lands would remain in Federal ownership for the major purpose of waterfowl management, and agricultural use would continue consistent with waterfowl management. In the 1950s, agricultural crops were viewed as a requirement for waterfowl in the Klamath Basin. In its report to the Secretary of the Interior, the U.S. Fish and Wildlife Service (1956b) recognized that waterfowl in the Klamath Basin fed largely on agricultural crops on the refuges, and it was desirable to maintain that agricultural land base to support the millions of waterfowl in the basin and to delay their migration into valuable private croplands further south in California. If refuge lands were transferred to private ownership, it was feared that human-caused disturbance would lower the capacity of those lands to support waterfowl and there would be no control over cropping patterns and practices (i.e., the types of crops grown, harvest dates, etc.). If the agricultural lands were maintained in government ownership, small grains could be maintained as a primary food crop for waterfowl (U.S. Fish and Wildlife Service 1956b). In summary, from the Service's perspective, the intent of the bill was to maintain and stabilize the management of refuge lands. Service Director Daniel Janzen's statement summarizes this vision: "*It* [Tule Lake NWR] *still has the heaviest waterfowl use of any area in the Nation. I want to emphasize that. This is so because of a combination of shallow water sumps and the adjoining 2,500 acres of agricultural land farmed exclusively for the birds, plus the 15,000 acres of farmland leased by the Bureau of Reclamation to local farmers and which is by agreement devoted to crops which after harvest provide a great deal of waste grain … We feel this refuge must remain intact and continue to be managed in such manner as it is now."* (Janzen 1962).

Ultimately, after more than a decade of proposals and debate, the Kuchel Act (Public Law 88-567, 16 U.S.C. 695K-r) (Appendix 1) was enacted on September 2, 1964. The Act states: *"It is hereby declared to be the policy of the Congress … to preserve intact the necessary existing habitat for migratory waterfowl in this vital area of the Pacific Flyway, and to prevent depredations of migratory waterfowl on agricultural crops in the Pacific Coast States"* (Sec. 1). The Act additionally states that Tule Lake and Lower Klamath NWRs *"…are hereby dedicated to wildlife conservation. Such lands shall be administered by the Secretary of the Interior for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith. Such lands shall not be opened to homestead entry"* (Sec. 2).

Based on language within the Kuchel Act, congressional testimony, and Interior and Service reports, it is clear that the intent of the Kuchel Act relative to Lower Klamath and Tule Lake NWRs was as follows:

1. To maintain permanent ownership, by the United States, of the lands and waters to maintain the waterfowl values of the refuges by dedicating the lands and waters to wildlife conservation and specifically for the major purpose proper waterfowl management.

2. To provide food and habitat that would prevent waterfowl crop depredation on agricultural lands within the Upper Klamath Basin. In addition, to manage the refuges to delay the southward migration of waterfowl into agricultural areas of the Central and Imperial Valleys of California.

3. To maintain the significant historic production of waterfowl on the refuges by allowing for favorable regulation of water levels in the Tule Lake sumps.

4. To give full consideration to optimum agricultural use that is consistent with the major purpose of waterfowl management; and, if consistent with proper waterfowl

management, continue the present pattern of leasing at a price or prices designed to obtain maximum lease revenues, except that not more than 25 per centum of the total leased lands may be planted to row crops.

5. To prevent further agricultural development of the Tule Lake sumps.

Refuge purposes as provided in the Kuchel Act

The Kuchel Act (Appendix 1) superseded some elements of the original EOs by creating refuge purposes that were more specific than the purposes provided in the EOs. The intent of Congress, in new more specific refuge purposes, is evident in the following language: "**Notwithstanding** any other provision of law…Tule Lake National Wildlife Refuge…[and]…Lower Klamath National Wildlife Refuge … are hereby dedicated to wildlife conservation. Such lands shall be administered…for the major purpose of waterfowl management…" [emphasis added] (Kuchel Act 695l).

The Kuchel Act provides that the refuges are

1. "… to preserve intact the necessary existing habitat for migratory waterfowl in this vital area of the Pacific flyway…." (Kuchel Act, Sec. 695k).
2. "…to prevent depredations of migratory waterfowl on the agricultural crops in the Pacific Coast States." (Kuchel Act, Sec. 695k).
3. "…dedicated to wildlife conservation." (Kuchel Act 695l).
4. …for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith" (Kuchel Act 695l).
5. "…consistent with proper waterfowl management, continue the present pattern of leasing the reserved lands…." (Kuchel Act 695n).
6. "…for waterfowl purposes, including the growing of agricultural crops by direct plantings and sharecrop agreements with local cooperators where necessary…." (Kuchel Act 695n).

Refuge acquisitions under other authorities

The majority of lands within Lower Klamath NWR were withdrawn from the public domain under EO 924, EO 2200, and the Kuchel Act. However, approximately 4,500 acres were acquired under the general authority of the Migratory Bird Conservation Act (16 U.S.C. 715a-715r). As a result, these acquired lands are under the Migratory Bird Conservation Act purpose: "... for use as an inviolate sanctuary, or for any other management purpose, for migratory birds" (Migratory Bird Conservation Act, 16 U.S.C. Sec. 715d).

Refuge purposes – Lower Klamath NWR

Given the previous discussion, refuge purposes for Lower Klamath NWR are:

1. "…as a preserve and breeding ground for native birds" (EO 924).
2. "…protection of native birds" (EO 2200).

3. "… to preserve intact the necessary existing habitat for migratory waterfowl in this vital area of the Pacific flyway…" (Kuchel Act, Sec. 695k).
4. "…to prevent depredations of migratory waterfowl on the agricultural crops in the Pacific Coast States" (Kuchel Act, Sec. 695k).
5. "…dedicated to wildlife conservation…for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith" (Kuchel Act 695l).
6. "…consistent with proper waterfowl management, continue the present pattern of leasing the reserved lands…" (Kuchel Act 695n).
7. "…for waterfowl purposes, including the growing of agricultural crops by direct plantings and sharecrop agreements with local cooperators where necessary…" (Kuchel Act 695n).
8. "... for use as an inviolate sanctuary, or for any other management purpose, for migratory birds" (Migratory Bird Conservation Act, 16 U.S.C. Sec. 715d).

Refuge purposes – Tule Lake NWR

Given the previous discussion, refuge purposes for Tule Lake NWR are:

1. "…as a refuge and breeding ground for birds…" (EO 4975).
2. "…as a refuge and breeding ground for wild birds and animals" (EO 5945).
3. "… to preserve intact the necessary existing habitat for migratory waterfowl in this vital area of the Pacific flyway…" (Kuchel Act, Sec. 695k).
4. "…to prevent depredations of migratory waterfowl on the agricultural crops in the Pacific Coast States" (Kuchel Act, Sec. 695k).
5. "…dedicated to wildlife conservation…for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith" (Kuchel Act 695l).
6. "…consistent with proper waterfowl management, continue the present pattern of leasing the reserved lands…" (Kuchel Act 695n).
7. "…for waterfowl purposes, including the growing of agricultural crops by direct plantings and sharecrop agreements with local cooperators where necessary…" (Kuchel Act 695n).

Chapter III Applying "wildlife conservation" purposes to refuge lands

Refuge purposes derived from the Kuchel Act are more specific than those in the Executive orders. The primary purpose of the refuges in the Kuchel Act is proper waterfowl management as indicated in the language of the Act (Sections 1, 2, 4 and 6), as well as the debate in Congress in formulating the legislation. The viewpoint of the Secretary, conservation organizations, and agricultural interests further south in California clearly prevailed over other interests whose desire was to convert portions of the refuges to private ownership through homesteading. While "proper waterfowl management" is the primary refuge purpose under the Act, the Kuchel Act also dedicates the lands to the broader purpose of wildlife conservation.

Section 2 of the Kuchel Act specifically states that, "*Notwithstanding any other provisions of law, all lands owned by the United States lying within the Executive order boundaries of the Tule Lake National Wildlife Refuge, the Lower Klamath National Wildlife Refuge, the Upper Klamath National Wildlife Refuge and the Clear Lake National Wildlife Refuge are hereby* ***dedicated to wildlife conservation****.* [Emphasis added.] *Such lands shall be administered by the Secretary of the Interior for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith."*

Although waterfowl management is clearly the primary purpose, these refuges are also dedicated to the more general purpose of wildlife conservation, particularly in those areas not used as leased agricultural lands. During congressional testimony for S. 1988 (Kuchel Act), Secretary Udall spoke of the additional wildlife values of the refuges in Klamath Basin NWR Complex (which include Tule Lake and Lower Klamath NWRs) by stating, "*Nearly 250 different kinds of birds have been recorded on these refuges including 22 kinds of shorebirds, ... and 25 different species of hawks and owls. Over 160 species have been recorded as nesting*." He additionally stated, "*Thousands of grebes—eared, western, and pied-billed—nest on Tule Lake. These species are again becoming common on Lower Klamath where they once nested in great numbers. This lake was drained and remained dry from 1921 to 1942, and bird populations have, in many instances, been slow in recovering*." (Udall 1962, page 21). The Service interprets these statements to mean that the refuges are to be managed for "wildlife conservation" but that waterfowl are to receive priority in management. In other words, **if there is a conflict in providing habitats to various groups of wildlife, waterfowl objectives are met first—before meeting the needs of other wildlife groups.**

In implementing habitat management planning on the refuges within the broader language of "wildlife conservation," the Service will develop management programs consistent with Service policy and legal mandates. Service policy on achieving the Refuge System mission, goals, and purposes is defined in 601 FW 1. Specifically, Refuge System goals are to:

A. Conserve a diversity of fish, wildlife, and plants and their habitats, including species that are endangered or threatened with becoming endangered.

B. Develop and maintain a network of habitats for migratory birds, anadromous and interjurisdictional fish, and marine mammal populations that is strategically distributed and carefully managed to meet important life history needs of these species across their ranges.

C. Conserve those ecosystems, plant communities, wetlands of national or international significance, and landscapes and seascapes that are unique, rare, declining, or underrepresented in existing protection efforts.

D. Provide and enhance opportunities to participate in compatible wildlife-dependent recreation (hunting, fishing, wildlife observation and photography, and environmental education and interpretation).

E. Foster understanding and instill appreciation of the diversity and interconnectedness of fish, wildlife, and plants and their habitats.

To achieve the Improvement Act's mandate to maintain the biological integrity, diversity, and environmental health of the Refuge System, refuge managers are guided by Service policy FW 601 3, which states, "*The policy is an additional directive for refuge managers to follow while achieving refuge purpose(s) and System mission. It provides for the consideration and protection of the broad spectrum of fish, wildlife, and habitat resources found on refuges and associated ecosystems. Further, it provides refuge managers with an evaluation process to analyze their refuge and recommend the best management direction to prevent further degradation of environmental conditions; and where appropriate and in concert with refuge purposes and System mission, restore lost or severely degraded components.*"

Chapter IV Definition of "proper waterfowl management"

Tundra swans, Lower Klamath National Wildlife Refuge. Photo by Dave Menke, U.S. Fish and Wildlife Service

Over thousands of years, Native Americans harvested North American waterfowl as a food resource and for other purposes. Generally, populations of Native Americans were insufficient or they lacked the technologies to seriously deplete waterfowl numbers. That changed with European immigration to North America and the evolution of firearms. Early in the 20th century, unregulated commercial harvest (market hunting) severely depleted waterfowl numbers. Nationally, market hunting and associated decline in populations, coupled with losses of hundreds of thousands of waterfowl to avian disease annually, particularly avian botulism in the western United States (Bolen 2000), raised significant concerns over the future of waterfowl in North America. These concerns were central to the development and evolution of waterfowl management as practiced today.

To define "proper waterfowl management" in contemporary terms, the Service used three approaches: (1) an evaluation of the scientific literature, (2) review of the goals of the North American Waterfowl Management Plan (NAWMP), and (3) expert opinion gathered from a series of waterfowl management workshops involving refuge staff and waterfowl managers and biologists from the Pacific Flyway.

Review of pertinent literature

Food habits and the dietary needs of waterfowl: In its infancy, the science and practice of waterfowl management placed considerable emphasis on providing foods waterfowl consumed as a basis for habitat management. Food habit studies of waterfowl were initiated in the early 1900s by the U.S. Bureau of Biological Survey (McAtee 1911, 1914, 1915) with the first large scale studies completed in 1939 (Cottam 1939, Martin and Uhler 1939). Most of the thousands of samples in these early studies were collected during the fall and winter hunting seasons from the gizzard and esophagus of waterfowl. Although these early studies subsequently were found to have shortcomings, they identified important waterfowl foods and formed the foundation for habitat management and protection for many years.

Work by Swanson and Bartonek (1970) identified significant biases in early food habit studies by documenting that soft foods such as aquatic invertebrates were quickly digested, often prior to reaching the gizzard. Thus, it was formally recognized that early food habit studies were biased towards hard seeds or food items that were maintained in the gizzard for longer periods of time. Bartonek (1968) determined that 95 percent of food habit studies conducted prior to 1965 were based on analyses of gizzard contents. Thus, these early studies concluded that plant material was the dominant component of waterfowl foods. Using new protocols for food habit studies, a host of additional studies were launched that examined food resource needs of waterfowl, including during other seasons of the year, particularly the breeding season. This improved understanding of the foods consumed by waterfowl, coupled with the nutritional content of food resources and the dietary needs of waterfowl, led to an evolution in how waterfowl habitats were managed.

Waterfowl use several basic food types, including aquatic and terrestrial invertebrates, seeds, agricultural foods, and other plant parts. Each food type provides different benefits depending on nutritional value, species of waterfowl, and requirements during the annual life cycle. During fall and winter, many waterfowl species, and especially geese, have adapted their feeding behavior to the availability of cereal grains (Baldassarre and Bolen 2006), using these foods when the need for carbohydrates is high. Agricultural foods are now a primary constituent of foods available in many of the major waterfowl wintering and migration areas of North America. Agriculture provides foods that are high in metabolizable energy (net energy available after subtracting energy required for digestion and absorption and that which is excreted) and are readily available (Reinecke et al. 1989). However, agricultural foods do not contain sufficient protein or required amino acids to satisfy nutritional requirements for wintering waterfowl (Baldassarre et al. (1983). Agricultural foods generally contain less than 10 percent protein, whereas protein content of most natural seeds range from 10-20 percent (Fredrickson and Taylor 1982), and those of aquatic invertebrates often exceed 50 percent (Krapu and Swanson 1975). However, because agricultural foods are readily available and abundant, waterfowl can often satisfy foraging needs more rapidly in croplands than in other habitats (Baldassarre and Bolen 2006). Baldassarre and Bolen (2006) summarized this trade off among food resources; "… *although managers should manage agricultural foods for waterfowl, such food sources are no substitute for the long-term benefits of foods provided in natural wetland habitats*."

Invertebrates, primarily aquatic but also terrestrial at times, form an important food resource for waterfowl, particularly during the spring breeding season and in the diets of young waterfowl.

Invertebrates are high in protein, often exceeding 50 percent (Krapu and Swanson 1975). Newly hatched ducklings consume invertebrates almost exclusively, with the proportion of invertebrates in their diet decreasing with age (Chura 1961, Collias and Collias 1963). Aquatic invertebrates such as midge larvae (*Chironomidae*), water boatman (*Corixidae*), and scuds (*Amphipoda*) contain 56 percent, 72 percent, and 47 percent protein, respectively, and provide a complete array of amino acids (Sugden 1973). Amino acid composition is especially important during egg production (Sedinger 1984) and during molt (Reinecke et al. 1989, Heitmeyer 1988). Natural foods, like invertebrates and natural seeds, provide a more complete array of amino acids and minerals than do agricultural grains (Baldassarre et al. 1983).

Non-agricultural seeds include native and exotic seeds found in both seasonal and year-round flooded wetlands; however, the greatest quantity and diversity is generally found in seasonal wetlands. Seasonal (often termed “moist-soil”) wetlands are dewatered in late spring to provide for the growth of desired annual, seed-producing plants. Seeds from seasonal wetlands provide a greater quantity and quality of protein than agricultural crops (Fredrickson and Taylor 1982); however, their metabolizable energy is generally less than agricultural foods.

Other waterfowl foods, including tubers, roots, rhizomes, stems, and leaves, are also important waterfowl food items (Baldassarre and Bolen 2006). Sago pondweed (*Potamogeton pectinatus*) is an important food for waterfowl, particularly for diving ducks and swans, throughout the Intermountain West, including Lower Klamath and Tule Lake NWRs. In addition, spring migrating geese use newly sprouted green vegetation (typically grasses and legumes) for the high protein content of this forage.

Habitat management for waterfowl: Wetlands form the primary natural habitat for waterfowl. However, wetlands are extremely diverse in their geographic scope and complexity. Wetlands of the Great Basin (also termed the Intermountain West and including the Klamath Basin), are somewhat unique in North America. Wetlands in this region are widely scattered among otherwise arid and semi-arid landscapes. As such, wetlands are extremely valuable as stepping stones in migration, as waterfowl transition between northern nesting areas and southern wintering grounds in the Pacific Flyway (Bellrose 1976).

Many wetlands in the Intermountain West have been physically and hydrologically altered and typically compete with agriculture for scarce water supplies (Kadlec and Smith 1989). Wetlands of the Klamath Basin are no exception. Historic Lower Klamath and Tule Lakes have essentially disappeared, having been replaced with managed wetland impoundments and return-flow sumps related to the Klamath Project’s agricultural purposes. Wetland managers now face the challenge of attempting to emulate historic wetland hydrology and function, and manage a much smaller complex of wetlands for myriad plant and animal species (Laubhan and Fredrickson 1993). The reduction of wetland habitats throughout North America, coupled with the high demand for abundant waterfowl populations from both the hunting and non-hunting public, has necessitated that the remaining habitats be optimally managed to produce and sustain waterfowl. The changing nature of wetlands throughout North America is discussed in Fredrickson and Reid (1990):

“… productivity of our national wetland resource has been severely impacted because the natural hydrology that resulted in wetland formation, and to which myriad plants and animals

have adapted, has been compromised. Developments such as dams for hydropower and flood control, diversions to speed water flow, levees for flood protection, wetland drainage for commercial districts and agriculture, and filling wetlands for marinas have modified wetlands across the continent. These destructive processes have been so complete within the 48 conterminous states that all watersheds have been degraded to some degree and few wetlands have retained either their natural hydrology or productivity. Because of these modifications in natural hydrological regimes, intensive wetland management is essential in many regions if wetlands are to retain their values and productivity."

The managed habitat complex: The natural hydrology of Lower Klamath and Tule Lake NWRs is highly altered, being replaced with an extensive network of Klamath Project related infrastructure. This fact, coupled with different habitat requirements and physiological needs of the multitude of waterfowl and other wetland wildlife species, necessitates the need for active habitat management. "*One of the greatest challenges facing wetland managers today is to provide the resources required for different waterfowl, including individuals of varying physical condition and social status, that utilize a single wetland complex*." (Reid et al. 1989).

A mix of habitats is desirable for several reasons. Habitat complexes tend to be complimentary, with the strength of one habitat complementing the weakness in another. For example, while agricultural habitats can provide the greatest energy per acre, wildlife diversity is low. In contrast, food energy densities are lower in wetlands, but the diversity of foods provided and number of wildlife species is greater (Reinecke et al 1989). "*Various types of wetlands are required to match the seasonal needs of waterfowl and, for optimal production, the appropriate types must be included on those public and private landscapes managed for waterfowl*" (Bolen 2000). Because agricultural foods contain insufficient protein and/or a full complement of required amino acids (Baldassarre it al. 1983) and support a relatively limited assemblage of waterfowl species, experts believe that agricultural crops should be limited to the minimum necessary to satisfy food production objectives that cannot be provided from more "natural" foods (Reinecke et al. 1989).

The primary habitat management question then becomes: what are the appropriate diversity, juxtaposition, and quantities of habitats to support the desired numbers and diversity of waterfowl species (as well as other species using the refuges). Despite the relative abundance of agricultural foods and their high caloric content, waste grains lack essential nutrients found in wetland oriented foods (Baldassarre et al. 1983). Thus, comprehensive habitat management plans should provide sources of natural foods found in wetlands (Baldassarre and Bolen 2006). "*Overall, management of waterfowl and other wetland wildlife in agricultural settings depends on striking a balance between food available as waste grains and food available in wetlands; for managers, this includes issues of species diversity and ecology…*" (Baldassarre and Bolen 2006).

Agriculture and waterfowl management: Under the Kuchel Act, the present pattern of agricultural leasing, optimizing agricultural use, or maximizing lease revenues must each be consistent with the refuges' major purpose of "proper waterfowl management. In the 1950s and 1960s, the wetlands provided in the sumps on Tule Lake NWR and surrounded by the leased agricultural lands were the optimal fall waterfowl habitat in the Pacific Flyway, as evidenced by large waterfowl populations.

During the 20th century, a reduction in wetland acres throughout the Pacific Flyway (particularly in California) coupled with large numbers of waterfowl produced in the northern prairies of Canada and the United States, forced migrating waterfowl into limited habitat areas during the fall, winter, and spring. In response, some waterfowl—principally mallards, pintails, wigeon, and geese—switched from feeding in wetlands to field feeding on small grains and other crops (Baldassarre and Bolen 2006). Agricultural foods are now a primary constituent of foods used by waterfowl in many of their major wintering and migration areas of North American.

Despite the benefits that many waterfowl derive from agricultural foods, given a choice, feeding in farmlands is not preferred, particularly in a dryland setting. Baldassarre and Bolen (2006) determined that the tendency for waterfowl to field feed is directly related to the abundance and availability of foods in natural habitats. In the Mississippi Alluvial Valley, mallards feed in dry agricultural fields only after flooded foraging sites are unavailable due to drought or the onset of cold weather (Reinecke et al. 1989). The following quotation typifies the sometimes tenuous connection between waterfowl and agricultural landscapes, "*Waterfowl migration and wintering habitats, many of which have already lost the vast majority of their wetlands, are being further threatened by invasive plant species, degraded water quality and diminished water supplies. The food and energy demands of non-breeding waterfowl are often met by the seasonal availability of agricultural foods – a resource with an uncertain future dependent on supply and demand, farming technology and irrigation water*." (NAWMP 2012a)

Key points from literature review:

1. Waterfowl are comprised of a series of broad guilds, including dabbling ducks, diving ducks, geese, and swans, each having different habitat and foraging requirements.

2. Because extensive areas of wetlands have been drained or severely compromised, active habitat management practices are required on the remaining acres to provide maximal benefits to waterfowl and other wetland dependent species.

3. To meet the multifaceted habitat and foraging needs of waterfowl, a diverse complex of habitats is required.

4. Where waterfowl make extensive use of agricultural landscapes, waterfowl managers must strike the proper balance of habitats for waterfowl.

An evolving paradigm for waterfowl management

The North American Waterfowl Management Plan: During the mid-1980s, drought returned to the primary waterfowl production areas of North America, resulting in declines in waterfowl populations. This led to a renewed interest in preserving wetland habitats on both northern production areas and more southerly migration and wintering habitats. It was also recognized that a new, more comprehensive approach was needed to preserve and enhance wetlands. Future waterfowl habitat protection and enhancement would require participation from a broader constituency. The relatively small acreage of state- and federally-owned wildlife areas was simply insufficient to preserve and restore waterfowl populations. Thus, the North American Waterfowl Management Plan (NAWMP, Plan), signed by the United States and Canada (1986) and by Mexico in 1994, seeks to restore duck populations to levels of the 1970s and goose and swan populations consistent with populations of the early 1980s and species population management plans. The overall aim of this continental habitat program is to maintain and manage an appropriate distribution and diversity of high quality waterfowl habitat in North America that will (1) maintain current distributions of waterfowl populations, and (2) under average environmental conditions, sustain an abundance of waterfowl. The NAWMP seeks to ensure habitat for 62 million breeding ducks on the continent and a fall flight of more than 100 million ducks, as well as sufficient habitat to support more than 6 million wintering geese and 60,000 wintering swan in the Western United States. NAWMP forms the foundation for waterfowl habitat and population management in North America. The NAWMP (1986) designates wetlands of the Klamath Basin as areas of international significance for waterfowl (NAWMP 1986).

The NAWMP is updated in response to changes across the landscape and in use patterns among waterfowl, new scientific information, and evolving societal desires (see NAWMP 1994, 1998, 2004, and 2012a). The most recent NAWMP (2012a) update represented a review and revision of plan goals, placing more focus on the need to better incorporate changing societal needs into waterfowl management. This most recent update includes three primary goals:

Goal 1: Abundant and resilient waterfowl populations to support hunting and other uses without imperiling habitat.

Goal 2: Wetlands and related habitats sufficient to sustain waterfowl populations at desired levels, while providing places to recreate and ecological services that benefit society.

Goal 3: Growing numbers of waterfowl hunters, other conservationists, and citizens who enjoy and actively support waterfowl and wetlands conservation.

Also included in the 2012 NAWMP update are a series of Plan principles, including:

1. Waterfowl are among North America’s most observed and highly valued natural resources.
2. Waterfowl management is a complex enterprise involving multiple governments, people, waterfowl populations, wetlands, and other habitats. These elements are highly interdependent and should be managed in a coherent, integrated manner.
3. Resident and endemic species also are important components of each nation’s waterfowl resource and deserve conservation emphasis from within the jurisdictions where they occur.
4. Managed harvest of the waterfowl resource is desirable and consistent with its conservation.
5. Maintenance of abundant waterfowl populations is dependent on protection, restoration, and management of habitat and the support of people who use and value these resources.
6. Primary vehicles for accomplishing Plan objectives will include partnerships within and among three key waterfowl management arenas: habitat conservation, population management, and resource users.
7. Long-term protection, restoration, and management of waterfowl habitats requires that Plan partners collaborate with conservation and community efforts in the development of

conservation, economic, and social policies and programs that sustain the ecological health of landscapes.

8. Sound science and knowledge is the foundation for planning, implementing, and evaluating the NAWMP programs.
9. Programs that manage waterfowl populations, habitats, and recreational users should embrace and employ adaptive management. Making progress toward Plan goals requires an unwavering commitment to support essential monitoring and assessment activities.
10. Waterfowl should be managed consistent with the North American Model of Wildlife Conservation.

Also in 2012, the NAWMP Action Plan (2012b) was completed to provide initial guidance and strategic ideas for implementing the NAWMP 2012 update. In completing the 2012 update, the authors convened a series of nationwide workshops. Two-thirds of the workshop participants (waterfowl managers and biologists) believed that the NAWMP should include numeric distribution objectives for breeding, migration, and wintering areas. It was believed that this would allow the joint ventures to apportion population and habitat objectives within specific larger geographic areas that would then link back to continental population objectives (see Petrie et al. 2011). "*Since the initial specification of population objectives in 1986, a key challenge to NAWMP implementation has been the development of a consistent and cohesive set of regional habitat objectives necessary to achieve continental population objectives*." (NAWMP Action Plan 2012b)

Intermountain West Joint Venture: Habitat conservation and planning under the NAWMP is pursued through a series of regional and, in several cases, species specific joint ventures. The joint ventures are partnerships of State and Federal agencies, tribes, business, conservation groups, and individuals that combine resources and expertise to enhance waterfowl habitats. The Klamath Basin is situated within the Intermountain West Joint Venture (IMWJV).

Geographically, the IMWJV is the largest of the joint ventures, ranging from Canada to Mexico and encompassing the lands between the Cascade and Sierra mountain ranges to the west and the Rocky Mountains to the east. Winter in the IMWJV is typically severe, thus most waterfowl migrate elsewhere to winter, typically California, Mexico, and the Gulf Coast. The primary contribution of this area to continental populations is migration and breeding habitat.

Because waterfowl management philosophy has expanded to be more inclusive of other wetland dependent wildlife species (Baldassarre and Bolen 2006, NAWMP 2012a), all habitat joint ventures, including the IMWJV, have broadened their focus and are now considered "all bird" joint ventures. The IMWVJ is developing focal species lists and population objectives for waterfowl as well as non-game waterbirds (IMWJV 2012 in prep) with a particular emphasis on shorebirds (Oring et al. 2004) and colonial nesting waterbirds (Ivey and Herziger 2006). Non-game waterbirds are broadly grouped as shorebirds, gulls, terns, cranes, rails, herons, grebes, egrets, and ibis. Currently, Lower Klamath NWR is considered the most significant waterbird nesting site in California (Ivey and Herziger 2006).

Consistent with the NAWMP, which seeks to focus waterfowl conservation efforts in key areas, the IMWJV is developing waterfowl population and habitat objectives within the southern

Oregon and northeastern California (SONEC) region (Fig. 2). The planning effort is focused on use of the bioenergetic model TRUEMET (Central Valley Joint Venture 2006) as a tool to evaluate current habitat conditions for priority waterfowl species and to inform future habitat objectives. The TRUEMET model essentially matches waterfowl population objectives with food resources available. Although Tule Lake and Lower Klamath NWRs account for only a small fraction of the SONEC landscape, these refuges support a significant proportion of the waterfowl that use SONEC in fall and winter (Kadlec and Smith 1989, Fleskes and Yee 2007). Thus, population objectives for the SONEC region in fall/winter are essentially the fall/winter population objectives for Tule Lake and Lower Klamath NWRs. During spring migration, snow melt and precipitation creates a much larger wetland habitat base for waterfowl, thus population objectives for both refuges are only a portion of the SONEC region's overall total population objective. However, spring waterfowl use of Tule Lake and Lower Klamath NWRs is proportionally higher than any other subregion in SONEC (Fleskes and Yee 2007).

Key points from the NAWMP and associated IMWJV:

1. Because of the migrational nature of waterfowl, population management must be coordinated across broad landscapes.

2. Continentally, duck population objectives are based on populations experienced during the 1970s. Goose and swan populations may vary but are linked to flyway species management plans and are more reflective of current conditions.

3. Collective waterfowl population and habitat objectives are built from the ground up through the joint venture planning process.

4. Waterfowl management under the NAWMP also considers the full range of wildlife species associated with wetland habitats.

Fig. 2. Southern Oregon and northeastern California subregion within the Intermountain West Joint Venture.

Workshops with waterfowl managers and biologists from the Pacific Flyway

Expert opinion was gained through an initial workshop convened September 16-18, 2002. In attendance were waterfowl biologists and managers from the Pacific Flyway (Oregon and California) representing State and Federal agencies, as well as several non-governmental organizations. Considerable discussion focused on establishing waterfowl population objectives for Tule Lake and Lower Klamath NWRs, assessing the role of non-game waterbirds in wetland management, and using bioenergetic modeling to design and assess current and alternative habitat management strategies for waterfowl. Recommendations from the workshop resulted in implementation of specific projects, including an assessment of waterfowl foods produced from refuge habitats, establishing waterfowl population objectives, conducting a bioenergetic assessment of current and potential habitat management alternatives (see Dugger et. al 2008), and surveys to assess populations of non-game waterbird species (see Shuford et. al 2006). A second workshop was convened April 29-30, 2009, to review results of implemented studies and to solicit input to develop a contemporary definition of waterfowl management.

Key points from workshops:

1. Migratory waterfowl population objectives should be linked to the NAWMP through the IMWJV.
2. Objectives for breeding and molting waterfowl should be established.
3. Population objectives for other wetland dependent wildlife species should be developed and considered in waterfowl habitat management, especially those species that are not well served by habitats managed for waterfowl.
4. Use bioenergetic modeling to link populations to habitat needs.
5. Incorporate estimates of water needs relative to wetland habitat objectives.
6. “Proper waterfowl management” should include providing habitats and food resources to support the needs at all stages of the waterfowl life cycle, and management should be consistent with the goals of the NWAMP, IMWJV, and Pacific Flyway management plans.

Definition of “proper waterfowl management”

Based on the previous sources (expert opinion, literature review, and the NAWMP), the Service has determined that “proper waterfowl management” is defined as: ***providing habitats sufficient to support waterfowl population objectives throughout the annual cycle while promoting the highest possible natural biological diversity of refuge habitats. A sufficient quantity and diversity of foraging resources should be provided that will meet the energy requirements and nutritional demands of all waterfowl species. Where feasible, natural foods should be given priority over agricultural crops.***

Chapter V Defining agricultural purposes from the Kuchel Act

The Service believes that the major purpose of the Kuchel Act is waterfowl management as indicated in the language of the Act (Sections 1, 2, 4, and 6), as well as the debate in Congress in formulating the legislation. While "proper waterfowl management" is the major purpose of the Act, there are additional secondary refuge purposes related to agriculture derived from the Kuchel Act. The Kuchel Act directs that the Secretary continue the "present pattern of leasing," maximize lease revenues in specifically identified areas of the refuges, and optimize agriculture, all consistent with waterfowl management.

The "present pattern of leasing"

Since 1964, when the Kuchel Act was passed, the cropping pattern on the refuges has changed significantly (Tables 1 and 2). Leased land farmers have been allowed flexibility to select crops within the broad guidelines of the Kuchel Act, which allows, "*…for the growing of grain, forage, and soil-building crops, except that not more than 25 per centum of the total leased lands may be planted to row crops.*" (Sec. 4) For example, prior to 2005, barley was the principal small grain crop, which has now been replaced by wheat. Oats expanded in acreage in the 1970s as a rotation crop to reduce soil pest populations (nematodes) that were reducing barley yields. Since 1980, alfalfa, considered a soil-building crop, has expanded in acreage on Tule Lake NWR, again primarily driven by market conditions and a desire to control soil pests in small grains and row crops. It is clear from the language of the Kuchel Act and congressional testimony, including testimony from the Secretary (see Udall 1962), that leased agricultural lands were important to the local farm economy and served as a source of revenue to the adjacent counties; however, proper waterfowl management is the major purpose of the lands and any agricultural leasing must be consistent with that major purpose.

Because the Kuchel Act provides that agricultural leasing will continue in specific areas of the refuges if consistent with proper waterfowl management, the Service must continually evaluate agricultural uses and cropping patterns to ensure that they are consistent with proper waterfowl management. For the "present pattern of leasing" to be consistent with proper waterfowl management, the Service finds that the overall program must provide sufficient food resources to support population objectives for waterfowl (dabbling ducks and geese) during the spring and fall migration. In addition, post-harvest farming practices and other practices must be implemented that will increase the attractiveness of the fields for foraging waterfowl and disperse waterfowl use as widely in the leased lands as possible. Bioenergetic modeling approaches (see Chapter VII) such as presented by Dugger et al. (2008) could be used to evaluate the carrying capacity of the refuge's agricultural programs (including the refuge leased lands) for waterfowl.

Table 1. Crop history of Tule Lake and Lower Klamath National Wildlife Refuge leased lands, California and Oregon, 1980-2012. Alfalfa, onions, potatoes, and horseradish are only grown on Tule Lake NWR, while "other hay" (grass hay) is generally only grown on Lower Klamath NWR. Small grains are grown on both refuges. Data from Tule Lake Irrigation District and Klamath Basin National Wildlife Refuge files.

Year	Barley	Wheat	Oats	Rye	Sugar beets	Onions	Potatoes	Pea seed	Alfalfa	Horse-radish	Other Hay	**Total**
1980	10,435	646	3,697	3			2,291		371		3,529	20,972
1981	11,076	720	4,564			329	2,453		431		3,032	22,605
1982	11,236	533	4,972			441	2,603		492		2,503	22,780
1983	10,520	962	5,311			435	2,652		574		2,365	22,819
1984	10,502	750	5,147			134	2,945		660		2,311	22,449
1985	9,963	1,044	5,189			224	3,262		803		2,194	22,679
1986	9,238	1,431	3,168			647	2,788		704		2,217	20,193
1987	8,800	1,329	3,966			410	3,071		491		2,181	20,248
1988	10,704	835	3,956			573	2,436		401		2,075	20,980
1989	9,027	1,939	5,768			613	2,727		598		1,948	22,620
1990	9,941	1,942	4,429			614	3,037	53	666		1,940	22,622
1991	10,096	1,681	4,156		265	947	2,224		765		2,340	22,474
1992	11,491	1,930	2,948		456	160	2,226		707		1,940	21,858
1993	9,456	1,717	3,155		607	318	2,919		512		2,010	20,694
1994	9,798	1,797	2,927		699	134	2,893	102	749		1,819	20,918
1995	10,623	1,757	3,691		658	318	2,909		712		1,802	22,470
1996	10,277	2,054	3,110		818	387	2,625		906		1,806	21,983
1997	9,066	1,377	2,996		901	717	2,456		975		1,802	20,290
1998	8,342	2,667	2,280		648	868	2,467		960	13	1,802	20,047
1999	5,227	6,573	1,988		425	1,249	1,589	10	989	25	2,475	20,550
2000	7,011	4,017	2,504		141	993	1,945	10	1,306	34	2,717	20,678
2001	5,758	485	3,482	111					1,280	34	2,380	13,530
2002	5,775	5,177	2,832	61		265	1,535		2,090	33	2,185	19,953
2003	4,931	5,566	2,289	61		401	1,952		2,576	33	2,167	19,976
2004	4,601	6,971	2,239	73		374	1,754		3,237	33	2,126	21,408
2005	2,016	7,851	1,684	90		521	2,703		3,409	38	2,211	20,523
2006	1,964	8,345	1,656	72		745	2,973		3,592	38	2,253	21,638
2007	2,145	7,183	2,134	145		529	3,019		3,450	38	2,346	20,989
2008	1,960	8,432	820	72		1,222	2,729		3,324	38	2,031	20,628
2009	1,121	9,275	1,244			1,220	2,572		2,663	38	1,815	19,948
2010	4,642	4,666	1,664			218	755		2,413	30	1,802	16,190
2011	2,469	8,210	1,295	97		768	3,235		1,759	38	1,802	19,673
2012	3,156	7,031	1,516	33		1,049	2,822		1,651	38	2,026	19,322

Table 2. Crop history of Tule Lake NWR 1957-79. Data from Tule Lake Irrigation District and Klamath Basin National Wildlife Refuge files.

Year	Barley	Wheat	Oats	Onions	Potatoes	Alfalfa/hay	Total
1957	13,431	362	10	33	1,334		15,170
1958	13,702	112		33	1,128		14,975
1959	13,381	310		52	1,443	14	15,200
1960	13,563	720	8	68	1,381	17	15,757
1961	11,078	1,665	155	14	1,690	11	14,613
1962	11,865	1,447	4	55	1,194	11	14,576
1963	9,449	2,231			2,747		14,427
1964	11,174	682			2,566		14,422
1965	11,895	197		21	2,509		14,622
1966	12,152	174		21	2,057		14,404
1967	12,143	375			2,118		14,636
1968	10,803	1,430	163	96	2,140		14,632
1969	No data	650	766	144			Data incomplete
1970	11,060	409	2,982	125	2,157		16,733
1971	8,217	1,595	4,539	52	2,289	669	17,361
1972	9,811	1,446	3,479	212	1,856	431	17,235
1973	8,071	3,331	2,686	450	1,554	501	16,593
1974	6,703	3,870	3,140	468	1,506	902	16,589
1975	7,800	2,619	3,656	357	1,389	818	16,639
1976	8,501	2,296	3,453	34	1,480	673	16,437
1977	9,794	967	3,282	575	1,351	859	16,828
1978	9,458	956	2,938	630	1,889	791	16,662
1979	9,067	1,243	3,317	472	2,021	663	16,783

Maximizing lease revenues

The Kuchel Act provides that consistent with the proper waterfowl management, leases for refuge lands will be at a price or prices designed to obtain maximum lease revenues. Maximizing lease revenues and the cropping pattern on the leased lands are directly linked. During winter and early spring, agricultural leases are advertised for competitive bidding by Reclamation. Kuchel Act language is relatively broad related to crop types, allowing "…*for the growing of grain, forage, and soil-building crops, except that not more than 25 per centum of the total leased lands may be planted to row crops.*" (Sec. 4) To achieve maximum revenues, bids are selected based on the highest price. Changing market conditions and more efficacious agricultural technologies influence farm profitability, and thus the ability to bid competitively. Farmers that are successful in the bidding process are those who can adapt to changing conditions and technologies. Thus, maximizing revenues and broadly defined allowable crops results in an evolving cropping pattern on the refuge leased lands over time.

The Service believes it was the intent of Congress to maintain the leasing program on the refuges to the extent consistent with proper waterfowl management to support the economies of local rural communities and to provide revenue to adjacent Modoc, Siskiyou, and Klamath Counties. Some flexibility in crop types and the desire to maximize revenues both serve this intent; however, this intent is subject to the primary intent (major purpose) of proper waterfowl management. Thus, the needs of waterfowl are first assessed, and then lease contract stipulations regarding acreage, cropping patterns, and requisite management practices on the lands will need to be developed consistent with this assessment.

Full consideration for optimizing agricultural use

Section 2 of the Kuchel Act directs the Secretary to manage Tule Lake and Lower Klamath NWRs *"…for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith*." By allowing for the evolution of cropping patterns under the language of Section 4, which allows "…*for the growing of grain, forage, and soil-building crops, except that not more than 25 per centum of the total leased lands may be planted to row crops,*" the Service is providing full consideration to optimum agricultural use. However, there are limits to this optimization if it does not meet proper waterfowl management needs. On the refuge leased lands, the language of Section 4 and the five-year (one year annual renewal for four years) duration of most lease contracts has maintained the larger proportion of the lands in small grains. Numerous references by the Service, either in the congressional testimony or supporting documents (U.S. Fish and Wildlife Service 1956b), state the importance of small grains to waterfowl in the Klamath Basin and, in particular, on these two refuges. Similar to other agricultural related language in the Kuchel Act, the Service will provide "…*full consideration to optimum agricultural use…"* consistent with waterfowl management. Again, the Service will assess the needs of waterfowl relative to the leased refuge lands and then optimize agriculture to the extent consistent with proper waterfowl management and other applicable Service and Interior policies.

Chapter VI Habitat management and waterfowl use 49 years after the Kuchel Act

In evaluating habitat management for waterfowl under the Kuchel Act, an analysis of how waterfowl populations have responded to refuge management since passage of the Act is warranted. The following chapter describes general habitat management as it has occurred over the last 47 years for both refuges and describes use of the refuges by breeding and migratory waterfowl.

Lower Klamath NWR

Habitat management: With the exception of the portion of the refuge know as Area K (also termed the Straits Unit) (see Fig. 3), habitat management on Lower Klamath NWR is primarily guided by Section 4 of the Kuchel Act, which states: *"All other reserved public lands included in section 2 of this Act shall continue to be managed by the Secretary for waterfowl purposes, including the growing of agricultural crops by direct planting and sharecrop agreements with local cooperators where necessary*."

Management of these "*other reserved public lands,*" which comprise most of Lower Klamath NWR, has evolved over the decades because the Service has broad discretion over management of these lands for waterfowl. Management flexibility is high, with managers and biologists able to change habitat management practices as on-the-ground monitoring reveals the results of habitat management practices, as other new information is developed, or as the needs of waterfowl populations change. Basic habitat types consist of seasonal wetlands that are dewatered at various times in spring and reflooded in fall. This is the primary habitat for fall and spring migrant waterfowl. Other marshes are flooded year round and are the primary habitat used by diving ducks and as brood rearing habitat for waterfowl. Small grains are produced on a sharecrop basis; 25-33 percent of a crop is left unharvested and used by fall and spring waterfowl, primarily dabbling ducks and geese. Some areas are grazed or hayed to provide short stature grasses for spring migrant geese. The diversity and juxtaposition of typical habitats are depicted in Fig. 3.

In addition to the year-specific matrix of habitats, there is a rotational component to the program. In many areas, wetlands and croplands are rotated as a means of managing vegetative succession in wetlands, and year-round wetlands are periodically dewatered to enhance their productivity. Where possible, the hydrology of the refuge is managed to mimic what historically occurred within Lower Klamath Lake, when water levels reached annual lows in September and left approximately 50-60 percent of the lake bed dry. Natural reflooding would begin in September or October with the lake and marsh reaching annual high levels during March or April (Weddell 2000).

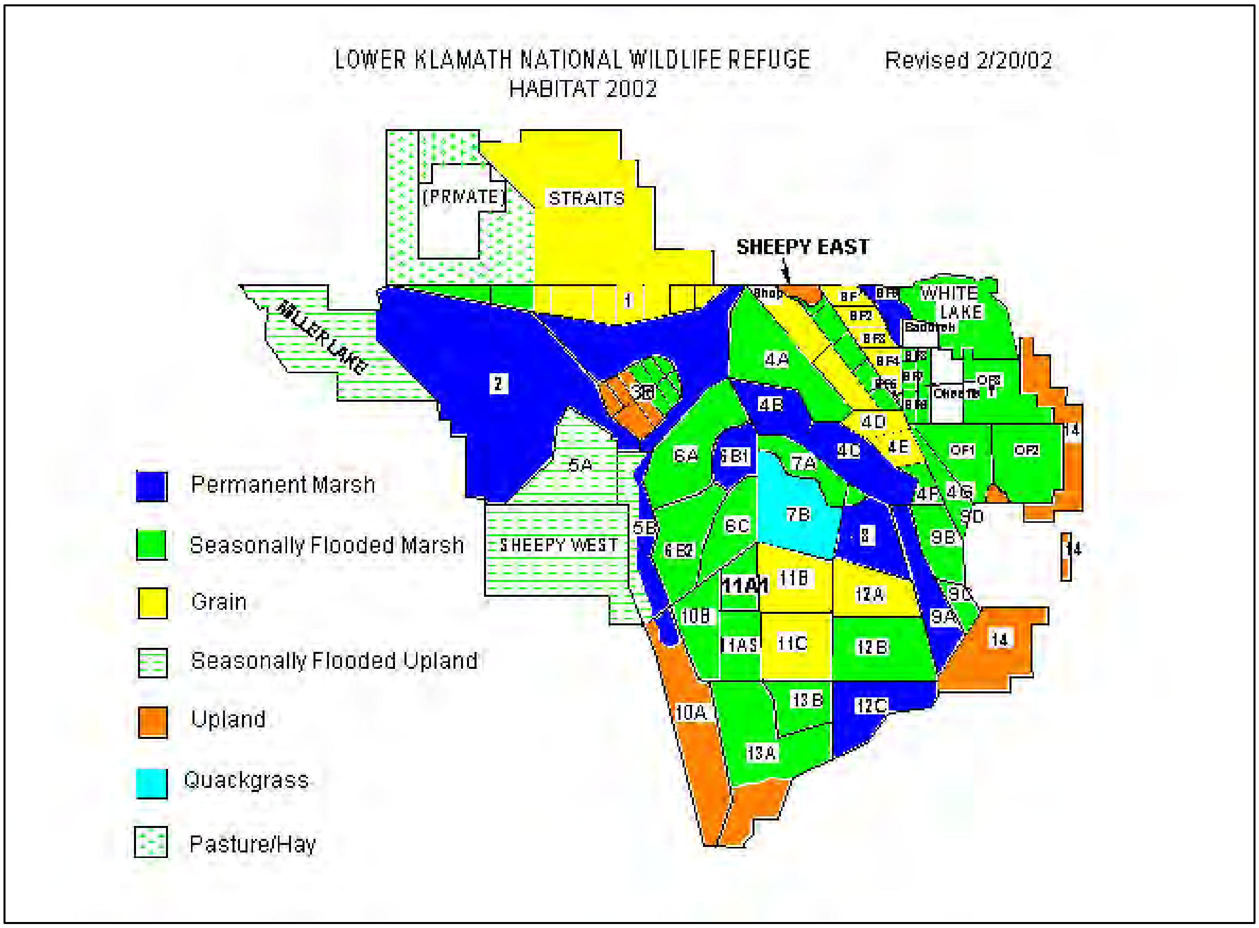

Fig. 3. Management units and typical habitats on Lower Klamath National Wildlife Refuge, California-Oregon, 2002.

Migratory waterfowl use: In examining waterfowl use on Lower Klamath NWR, the Service used data presented in Dugger et al. (2008) in which the authors compared the decade of the 1970s with the 1990s. The 1970s were chosen as the baseline year in which continental waterfowl populations were at NAWMP goals. The 1990s was chosen as the most recent decade in which refuge water supplies were at least comparable to the 1970s.

On Lower Klamath NWR, dabbler numbers have increased slightly between the 1970s and the 1990s census periods (Fig. 4). Goose use of Lower Klamath NWR has increased in spring (Fig. 5), while diving ducks have increased in all seasons (Fig. 6). Tundra swan use has increased in the spring period (Fig. 7).

In a more extensive review of the refuge's waterfowl census data, Gilmer et al. (2004) determined that most of the waterfowl use of the Klamath Basin shifted from Tule Lake to Lower Klamath NWR in the early 1980s and has remained there to the present day.

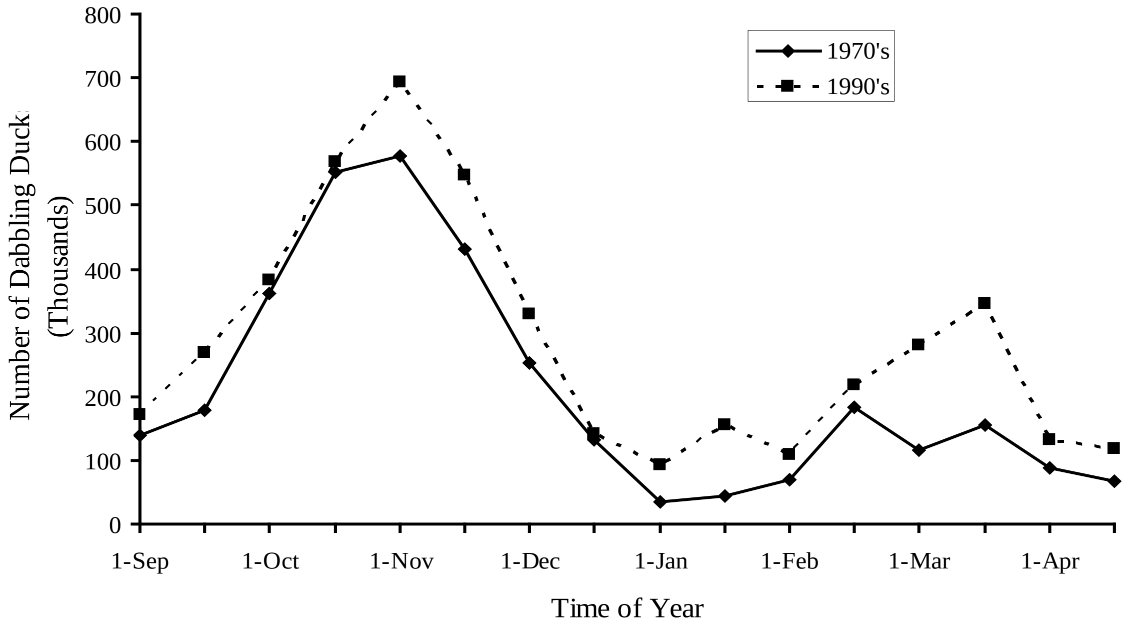

Fig. 4. Mean counts of dabbling ducks by date at Lower Klamath NWR in the 1970s (1970-1979) and 1990s (1990-1999) determined from aerial surveys (from Dugger et al. 2008).

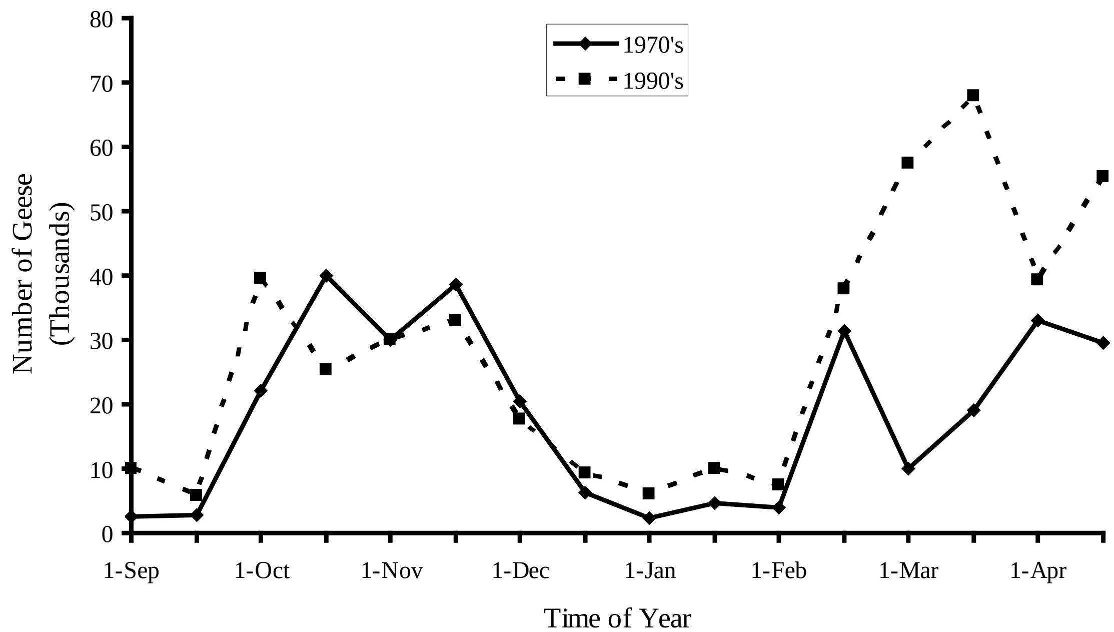

Fig. 5. Mean counts of geese by date at Lower Klamath NWR in the 1970s (1970-1979) and 1990s (1990-1999) determined from aerial surveys (from Dugger et al. 2008).

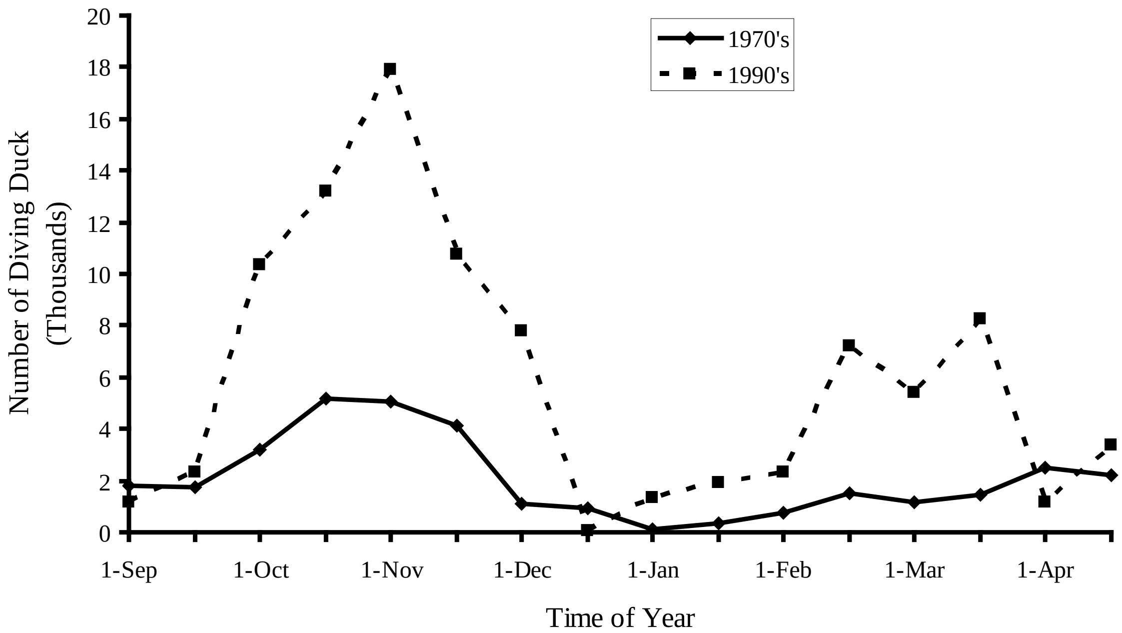

Fig. 6. Mean counts of diving ducks by date at Lower Klamath NWR in the 1970s (1970-1979) and 1990s (1990-1999) determined from aerial surveys (from Dugger et al. 2008).

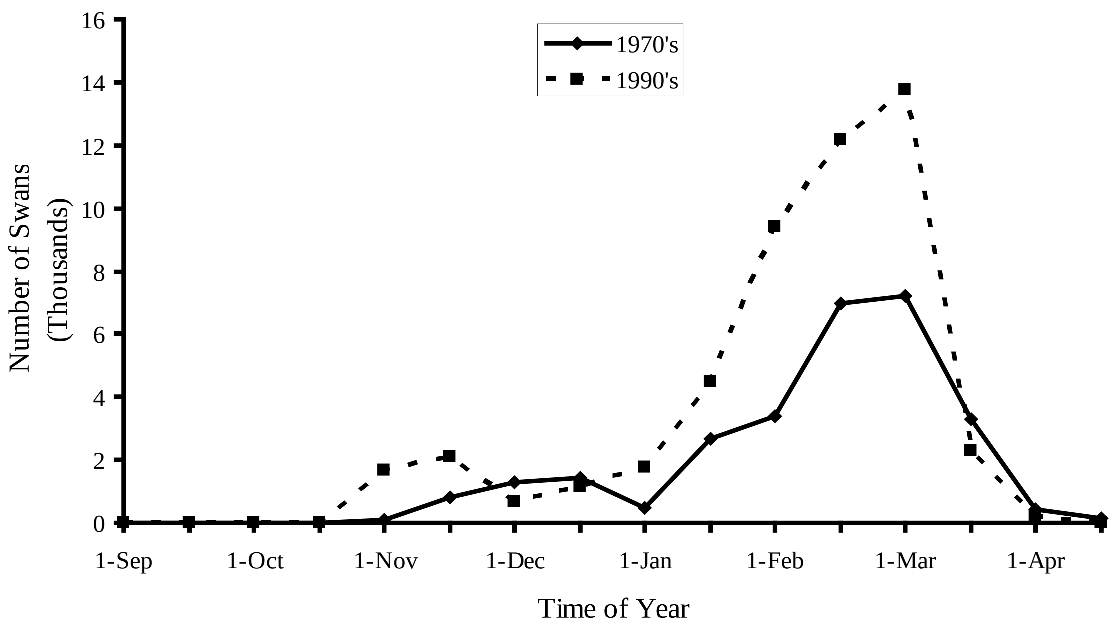

Fig. 7. Mean counts of swans by date at Lower Klamath NWR in the 1970s (1970-1979) and 1990s (1990-1999) determined from aerial surveys (from Dugger et al. 2008).

Breeding waterfowl: Lower Klamath NWR has a long history as a waterfowl production area in the Intermountain West (Jensen and Chattin 1964), and this value was discussed during Kuchel Act testimony (Janzen 1962)**.** Table 3 depicts estimated breeding pairs of the most common waterfowl using Lower Klamath NWR. From the 1950s through the 1990s, most species have remained relatively unchanged with the exception of gadwall, which increased over 500 percent in the 1990s. Ruddy ducks have declined approximately 75 percent from the 1970s.

Table 3. Estimated mean number of breeding pairs of waterfowl on Lower Klamath NWR for the 12 years prior to the Kuchel Act (1953-64) and the decade of the 1970s and 1990s.

Species	1953-64	1970-79	1990-99
Redhead	1,178	782	1,471
Ruddy duck	1,104	2,435	648
Mallard	1,054	1,534	2,454
Gadwall	1,770	1,672	11,321
Cinnamon teal	617	1,100	889

Tule Lake NWR

Habitat management: The foundation for habitat management on Tule Lake NWR is based on language in Section 4 of the Act, which states:

"*The Secretary shall, consistent with proper waterfowl management, continue the present pattern of leasing the reserved lands of the Klamath Straits unit, the Southwest sump, the League of Nations unit, the Henzel lease, and the Frog Pond unit, all within the Executive order boundaries of the Lower Klamath and Tule Lake National Wildlife Refuges and shown in plate 4 of the report entitled, "Plan for Wildlife Use of Federal Lands in the Upper Klamath Basin, Oregon-California," dated April 1956. Leases for these lands shall be at a price or prices designed to obtain the maximum lease revenues. The leases shall provide for the growing of grain, forage, and soil-building crops, except that not more than 25 per centum of the total leased lands may be planted to row crops.*"

Relative to the sumps on Tule Lake NWR, Section 5 states: "*The areas of sumps 1(a) and 1(b) in the Klamath project lying within the Executive order boundaries of the Tule Lake National Wildlife Refuge shall not be reduced by diking or by any other construction to less than the existing thirteen thousand acres*."

Section 6 states: *"…waters under the control of the Secretary of the Interior shall be regulated, subject to valid existing rights, to maintain sump levels in the Tule Lake National Wildlife Refuge at levels established by regulations issued by the Secretary pursuant to the contract between the United States and the Tulelake Irrigation District, dated September 10, 1956, or any amendment thereof. Such regulations shall accommodate to the maximum extent practicable waterfowl management needs."*

Thus, Tule Lake NWR waterfowl habitats are comprised nearly entirely of the leased lands and agricultural return flow Sumps 1(A) and 1(B), management of which is guided by Sections 4 (leased lands) and Sections 5 and 6 (Sumps 1(A) and 1(B)). The leased lands are managed primarily through agricultural lease contracts, and sump management and elevations are maintained consistent with the 1956 Tulelake Irrigation District (TID) contract, as amended, as well as interagency agreements between Reclamation and the Service. The ability to effect change under this framework is often slow and sometimes contentious. Nearly all of Tule Lake NWR is (and has been) managed under this basic framework since the early 1940s when the D pumping plant was constructed.

A major portion (more than half) of Tule Lake NWR's habitat acreage is a direct result of cropping patterns in the leasing program (Fig. 8, Table 1). In addition, the location and water elevations of the sumps have changed little since passage of the Kuchel Act. Essentially the Kuchel Act sought to freeze management in time such that waterfowl values of the refuge would be maintained. This made sense at the time because habitats on Tule Lake NWR, during debate and eventual passage of the Kuchel Act, supported one of the largest fall staging populations in North America. However, unlike Lower Klamath NWR, habitat management did not evolve over time with advances in the science and practice of waterfowl management. The assumption that Tule Lake NWR would continue to support robust waterfowl populations proved erroneous, and the refuge increasingly resembled a time capsule, showcasing waterfowl management from the 1950s and 60s. Specifically, management under the Kuchel Act assumed that:

- Dry agricultural fields would remain the preferred foraging habitat for waterfowl.
- Without active management, manipulating water levels, and/or habitat restoration of the sump, the Tule Lake sumps would remain productive for waterfowl.
- Waterfowl would remain the single goal associated with the practice of "waterfowl management."

Since the mid-1990s, the Service, in cooperation with TID and Reclamation, implemented significant projects that are beginning to improve habitats for waterfowl and other wetlands wildlife species. These include the current Walking Wetlands program, where wetlands are inserted into agricultural crop rotations, and the Sump 1(B) project, initiated in 1999, which allows for water manipulation at this 3,500-acre location. These efforts primarily focused on enhancing the diversity and productivity of wetland habitats. More work is needed to enhance the agricultural lands for waterfowl.

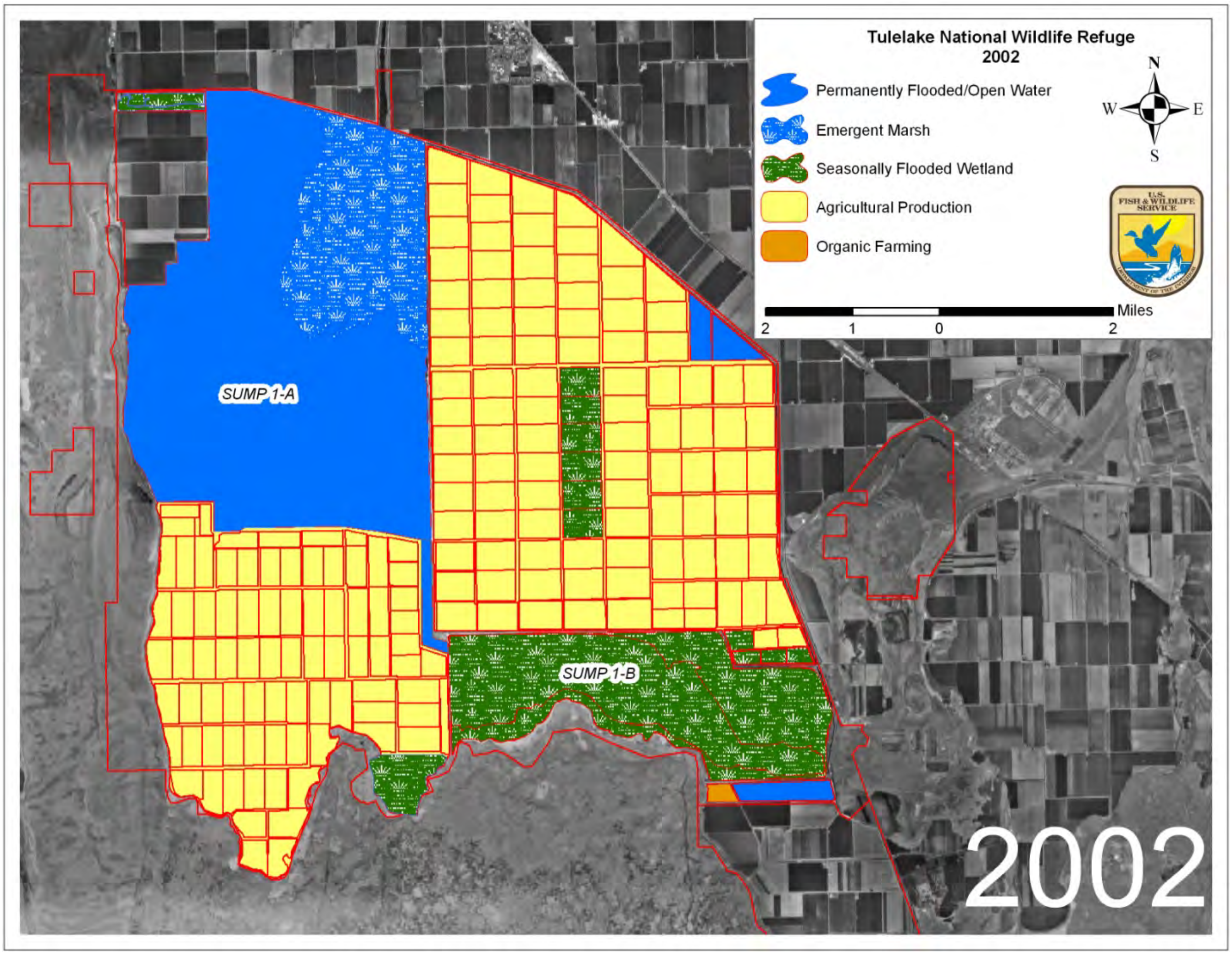

Fig. 8. Habitats of Tule Lake National Wildlife Refuge, 2002.

Migratory waterfowl use: A recent comparison of 1970s and 1990s population trends indicates that waterfowl use of Tule Lake NWR has changed significantly over time (Dugger et al. 2008). Especially notable are dabbler (Fig. 9) and goose use (Fig. 10), which have declined significantly compared to the 1970s. In contrast, diver numbers (Fig. 11) have increased, and swan use has remained relatively unchanged (Fig. 12). Guilds of waterfowl that make the greatest utilization of agricultural crops (geese and dabbling ducks) have undergone the most significant decline since the 1970s.

Changing cropping patterns (Tables 1 and 2) and harvest efficiencies on Tule Lake NWR and surrounding private lands, particularly in small grains, may be reducing the attractiveness and carrying capacity of the agricultural lands for waterfowl. In particular, small grains on surrounding private lands have been replaced by alfalfa and mint, particularly in the Tule Lake Basin. In addition, barley in the Klamath Basin has been replaced by wheat as the primary small grain crop grown. Modern combines are also more efficient in harvest than older combines were, potentially leaving less grain in fields after harvest. Krapu et al. (2004) compared 1978 corn harvest efficiencies in Nebraska to 1997-1998 efficiencies. Although average yields increased 20 percent, over the 20-year period, waste grain remaining in fields were 76 percent and 53 percent, respectively, of grain residues estimated in 1978. The authors believed this reduction in waste grain and corn acreage, coupled with competition from increasing numbers of other seed eating species (geese), was forcing sandhill cranes into longer foraging flights at higher energetic costs.

The role of agriculture in providing foods for large populations of staging waterfowl in the Klamath Basin was recognized by former Service Director Janzen, who stated during the congressional hearings on S. 1988, *"…15,000 acres within the refuge* [Tule Lake NWR] *is cash leased to local farmers by the Bureau of Reclamation. Following the harvest, waterfowl glean the lease lands stubble fields for waste grain. The lease areas provide space for waterfowl to disperse, loaf, and feed, and are particularly attractive and valuable to geese and field feeding species of ducks, such as mallards and pintails.*" (Janzen 1962, page 41). It seems reasonable to assume that agricultural practices, crop cultivars, and combine efficiency have advanced over the last 47 years, potentially leaving less grain in fields than occurred in the 1950 and 1960s. In fact, bioenergetics modeling work conducted by Dugger et al. (2008) on Tule Lake NWR indicates that small grain resources are currently insufficient to support waterfowl populations of the 1970s (see Chapter VII of this document), much less the much larger populations present during the 1950s and 1960s (Gilmer et al. 2004). Reduced standing grain acreage on Tule Lake NWR, historically farmed by either the refuge or its cooperators, may also have played a role in the reduced small grain food resources available.

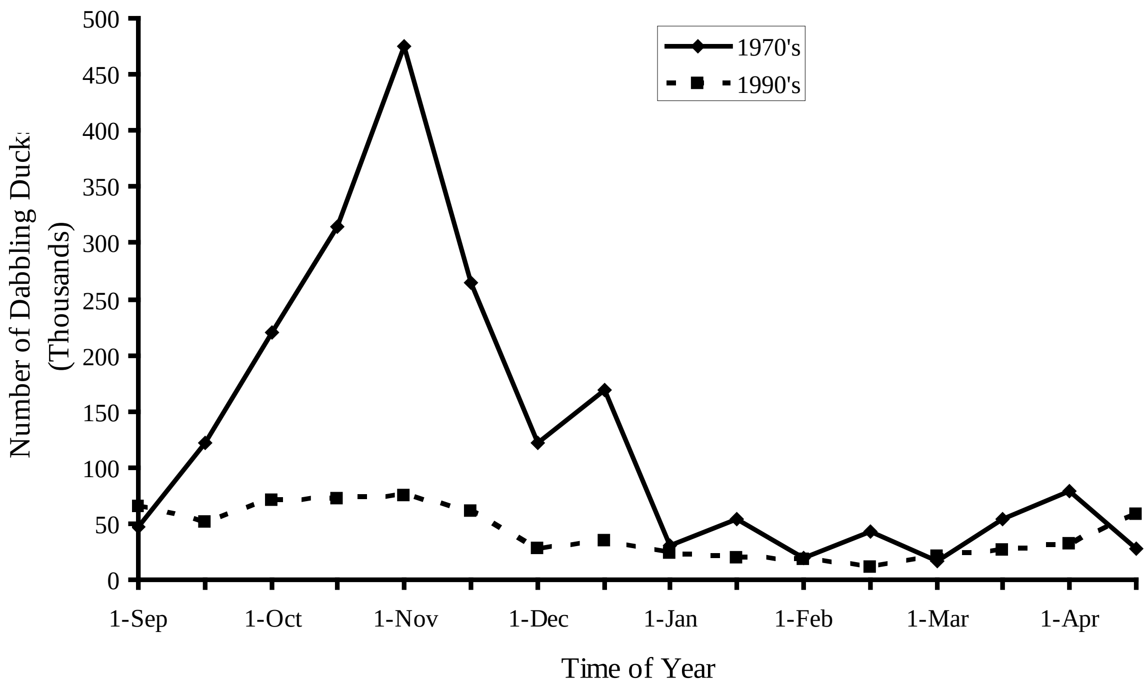

Fig. 9. Mean counts of dabbling ducks by date at Tule Lake NWR in the 1970s (1970-1979) and 1990s (1990-1999) determined from aerial surveys (from Dugger et al. 2008).

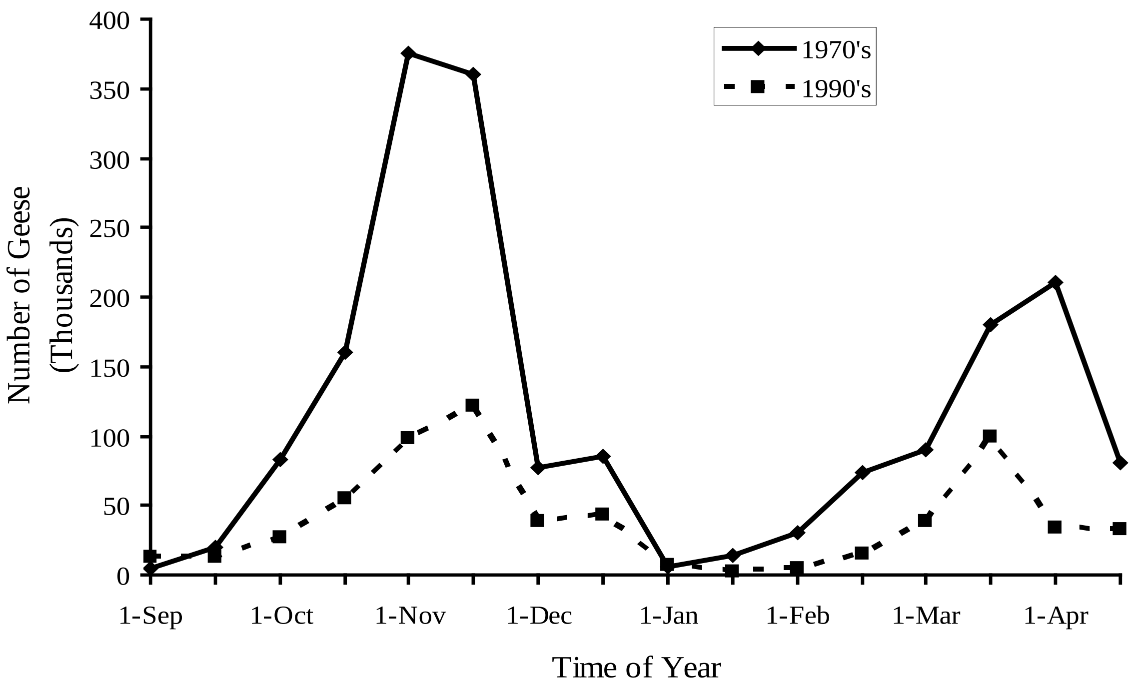

Fig. 10. Mean counts of geese by date at Tule Lake NWR in the 1970s (1970-1979) and 1990s (1990-1999) determined from aerial surveys (from Dugger et al. 2008).

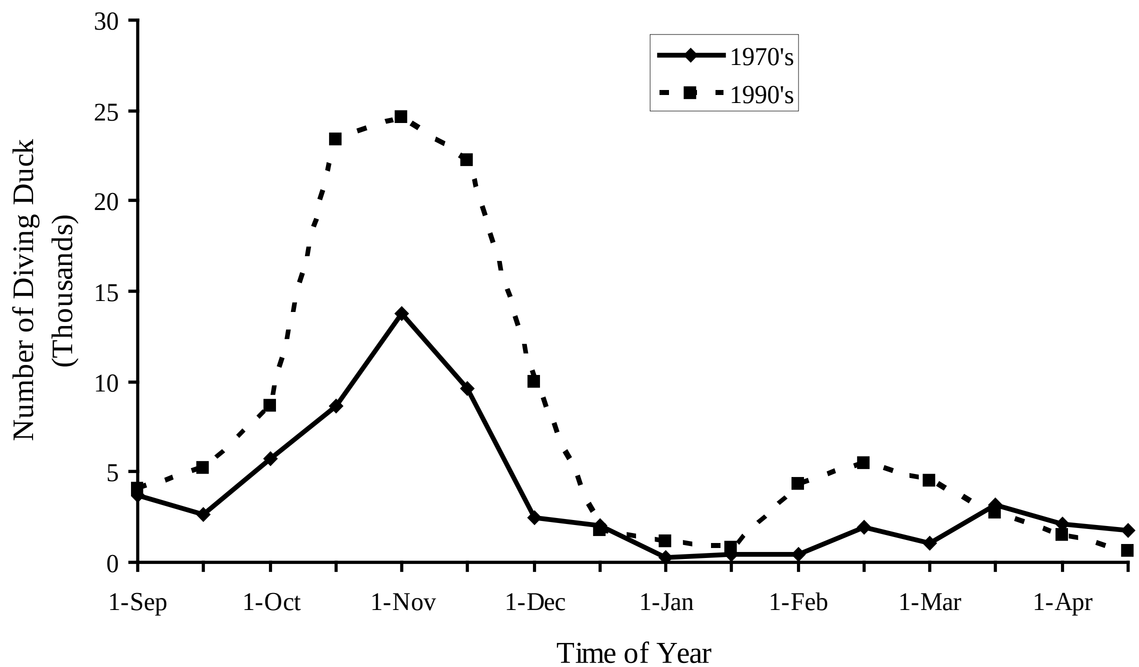

Fig. 11. Mean counts of diving ducks by date at Tule Lake NWR in the 1970s (1970-1979) and 1990s (1990-1999) determined from aerial surveys (from Dugger et al. 2008).

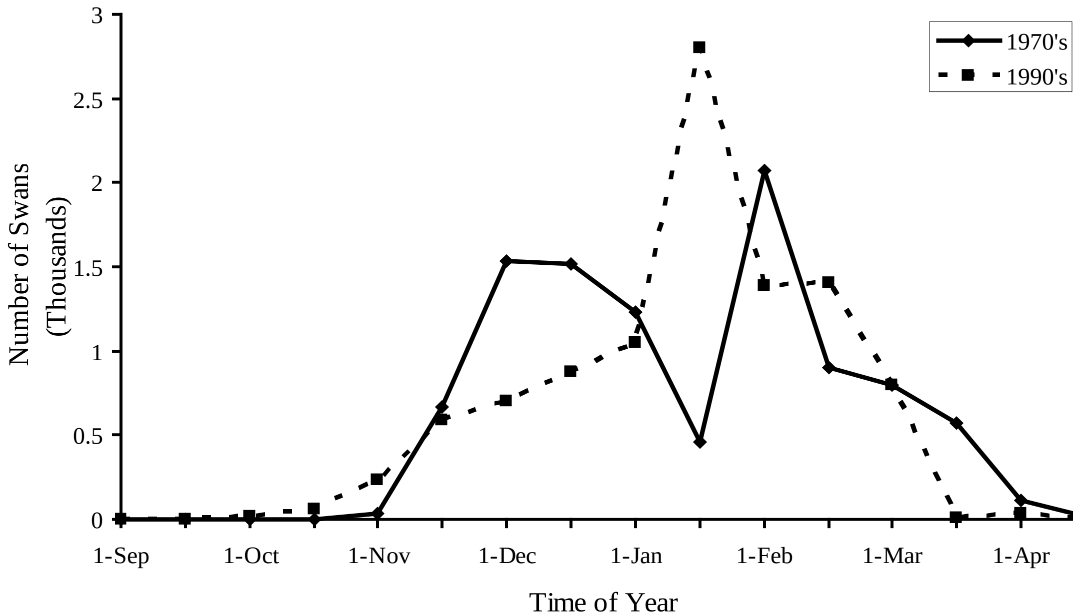

Fig. 12. Mean counts of swans by date at Tule Lake NWR in the 1970s (1970-1979) and 1990s (1990-1999) determined from aerial surveys (from Dugger et al. 2008).

Breeding waterfowl: Tule Lake NWR has a long history as a waterfowl production area within the Intermountain West (Jensen and Chattin 1964) and was discussed at length, particularly for breeding redheads, during congressional testimony for the Kuchel Act. Secretary Udall stated, "*The marshes of the Klamath Basin refuges rank among the best waterfowl production areas in the Nation, with the last 10-year average being 78,000 ducks and geese produced annually and peaks up to 112,000 earlier due to better nesting conditions. The Redhead, a species which is dwindling in numbers over much of its range, is the most abundant nester. Tule Lake, Lower and Upper Klamath, and Klamath Forest* [now Klamath Marsh NWR] *are key refuges in the preservation of this species, which require large marsh areas for survival."* (Udall 1962)

Similar to Lower Klamath NWR, breeding gadwall have increased over the years at Tule Lake NWR (Table 3). Breeding pairs of cinnamon teal and both common diving duck species (redhead and ruddy duck) have declined significantly. A likely cause of the decline in diving ducks is a reduction in the suitability of the sumps on Tule Lake NWR for breeding. Specifically, relatively stable water levels in the sumps have removed the very process that contributes to productive wetland habitats. Historically, fire, flooding, and drought created dynamic water regimes and wetland plant successional patterns to which wetland wildlife were adapted (Fredrickson and Reid 1990). Abney (1964), in a report completed shortly after the Kuchel Act was enacted, recognized that high stabilized water levels in the sumps had reduced the area of emergent wetlands from over 9,000 acres in the 1930s to approximately 2,500 acres by the late 1950s. In addition, sedimentation since passage of the Kuchel Act has reduced water depths in the remaining emergent marsh in Sump 1A to a fraction of that present in 1964, rendering this 2,500-acre marsh unsuitable as breeding or foraging habitat for diving ducks. The waterfowl production capacity of the sumps on Tule Lake was discussed at length during the Kuchel Act testimony and likely led to inclusion of Section 6 in the Act. Prior to the Kuchel Act, the

Service, Reclamation, and the Tule Lake Irrigation District were frequently at odds over management of water levels in the Sumps. The Service felt that rising water levels during the spring nesting period was flooding the nests of over-water nesting species such as diving ducks. Unfortunately, the Service's belief that stabilizing management of the sumps would ensure continued production of diving ducks proved unfounded.

Table 4. Estimated mean number of breeding pairs of waterfowl on Tule Lake NWR for the 12 years prior to the Kuchel Act (1953-1964) and the decade of the 1970s and 1990s.

Species	1953-1964	1970-1979	1990-1999
Redhead	1,350	635	161
Ruddy duck	1,503	3,092	315
Mallard	1,795	2,186	2,072
Gadwall	494	1,128	1,256
Cinnamon teal	610	667	200

Tule Lake NWR and the Pacific Flyway

Because waterfowl are migratory, reduced populations of fall staging geese and dabbling ducks may be caused by factors outside the Klamath Basin. Waterfowl are highly mobile and exploit a diverse array of wetland and non-wetland habitats over large geographic landscapes (Baldassarre and Bolen 2006). Thus, they are able to shift wintering and staging areas as available habitat changes within the Pacific Flyway. In North America, major waterfowl staging and wintering areas are often comprised of a mixture of wetlands and private agricultural lands. All waterfowl use wetlands as their primary habitat base for food, shelter, and other behavioral and physiological needs. Some waterfowl species are completely dependent on wetlands, while other species currently use a combination of wetlands and agricultural lands. Current goose populations are especially tied to agricultural lands, which they use from nearby wetland roost sites. Ringleman (1990) noted these large-scale shifts in waterfowl use patterns in North America, which often occurred in response to changes in agricultural practices and cropping patterns.

In the 1950 and 1960s, Tule Lake NWR represented optimal habitat for fall staging waterfowl in the Pacific Flyway, if not North America. The intent of the Kuchel Act was to preserve this "snapshot in time." The agricultural lands surrounding Sumps 1(A) and 1(B) supported literally millions of waterfowl at the peak of migration. However, the practice of wetland management for waterfowl and the science behind that management changed over time. This change was reflected in changing habitat management on Lower Klamath NWR and elsewhere in California, particularly in the Central Valley. Because the Central Valley is the primary wintering destination for waterfowl, habitat conditions there have a major impact on waterfowl populations in the Pacific Flyway, as well as how those birds move within the flyway.

During the 1800s, the Central Valley of California contained more than four million acres of wetlands that supported 20 to 40 million waterfowl annually. Agriculture and urban development reduced this wetland habitat by over 95 percent (Central Valley Joint Venture 2006). To address this issue, the Central Valley Joint Venture (CVJV) was established in 1988 as one of the six priority joint ventures under the NAWMP. Implementation of the CVJV has been hugely successful with 121,969 acres of wetlands protected, restored, or enhanced and more than 384,000 acres of agricultural lands enhanced for waterfowl between 1990 and 2003 (CVJV 2006). Of the agricultural enhancement, over 90 percent of the acres are comprised of fall and winter flooded rice. Miller et al. (2010) estimated that flooded rice fields increased 40 percent in 2007 compared to 1999-2000 and increased 90 percent over the fall-winter of 1993-94. In addition, passage of the Central Valley Project Improvement Act of 1992 significantly increased the reliability of water supplies for public and private wetlands in the Central Valley.

Tule Lake NWR experienced its highest fall waterfowl populations during the 1950s and 1960s when Central Valley wetland and agricultural habitat conditions were least attractive to wintering waterfowl. Subsequent improvements to Central Valley habitats appear to have strongly influenced fall waterfowl use of Tule Lake NWR and, to a lesser degree, Lower Klamath NWR. Spring populations, however, continue to increase in the Klamath Basin, particularly on Lower Klamath NWR. Thus, while other major waterfowl use areas of the Pacific Flyway have enhanced and expanded their habitats, management of Tule Lake NWR has remained relatively unchanged since the 1950s and 1960s.

In the case of Tule Lake NWR, the reduction of waterfowl use since the early 1970s can be attributed to several causes: (1) a lack of productive wetland habitats, (2) a lack of sufficient agricultural food resources (see Chapter VII), (3) improved wetland habitat conditions in the Central Valley of California, particularly in fall, and (4) increased attractiveness of Central Valley agriculture for waterfowl, primarily due to significantly increased acreage of early fall flooding of rice.

A large proportion of wintering waterfowl in the Pacific Flyway are now dependent on the food and habitat resources of private agricultural lands of the Central Valley. The future of these lands for waterfowl is not secure, as it is subject to changing agricultural market conditions, scarcity, and/or valuation of water for other uses in California, and other unforeseen circumstances. Changing conditions in this critical wintering area will alter how waterfowl use the Pacific Flyway and the Klamath Basin in the future.

Chapter VII Assessing current waterfowl habitat management using a bioenergetics model

In addition to assessing waterfowl use and habitat management of the refuges, the Service contracted with Oregon State University and Ducks Unlimited to examine the current carrying capacity of both refuges for waterfowl. More specifically, this project's objectives were to: (1) develop waterfowl population objectives for both refuges, and (2) evaluate current habitat management programs using the TRUEMET bioenergetics model (Dugger et al. 2008). Bioenergetics modeling is the current method used in both the Intermountain West and Central Valley joint ventures (Central Valley Joint Venture 2006) to estimate waterfowl habitat needs for specified population objectives.

Developing waterfowl population objectives

The Klamath Basin forms a natural funnel for the Pacific Flyway as migratory waterfowl transition from northerly breeding areas to major wintering sites in the Central Valley of California (Gilmer et al. 1982). Lower Klamath and Tule Lake NWRs represent key migrational spring and fall staging areas in the Klamath Basin and for the larger Pacific Flyway (Gilmer et al. 2004). Both refuges are unique in the Refuge System in having a long history of periodic aerial waterfowl surveys, dating as far back as the 1950s (Gilmer et al. 2004). Dabbling ducks are comprised primarily of mallard, pintail, wigeon, and green-winged teal. Major goose species include white-fronted snow, and Ross's goose. Divers are comprised primarily of canvasback, redhead, scaup, ruddy, and bufflehead; the tundra swan is the primary swan species on both refuges.

There are three primary reasons for establishing population objectives at Tule Lake and Lower Klamath NWRs. First, it will match habitats with desired waterfowl numbers; second, it will provide habitats in coordination with other flyway-wide habitat and population objectives; and third, it serves as a communication tool so that the public understands the basis for refuge habitat management programs. In establishing population objectives, of the factors that influence waterfowl use of an area, many are outside the control of refuge managers and biologists. For example, drought in northern breeding areas may reduce continental populations. Year-specific weather patterns may mean an earlier or later migration or cause waterfowl to shift migration and wintering areas. Landscape conditions in other areas of the flyway may influence populations at migrational staging or wintering areas. Many of these variables cannot be anticipated or influenced. Thus, it is not necessarily reasonable to expect to achieve exact specified population objectives every year.

At the individual refuge scale, matching habitats to population objectives is also desirable from an operational efficiency standpoint. If waterfowl objectives can be met with, for example, 70 percent of the refuge's land area, the other 30 percent could be used to meet the broader refuge purpose of "wildlife conservation" under the Kuchel Act.   At a flyway scale, Tule Lake and Lower Klamath NWRs are primarily migration habitat and should be providing sufficient foods and habitats to sustain desired Pacific Flyway populations as the birds migrate either south to wintering areas or north in spring to breeding areas.

The NAWMP update (2012) recommends that joint ventures, including the IMWJV, step down continental waterfowl population objectives to joint venture objectives. The IMWJV has begun this process with population objectives for key migrational staging areas, which includes the SONEC region (Fig. 2) of which the Klamath Basin is a key part. Population objectives for Tule Lake and Lower Klamath NWRs represent a portion of the total objectives for the larger SONEC region. Waterfowl population objectives developed for Tule Lake NWR (Table 5) and Lower Klamath NWRs (Table 6) are consistent with objectives of the NAWMP, as well as planning efforts within the Intermountain West and the Pacific Flyway.

Migrating ducks: Aerial surveys from the 1970s conducted once every two weeks were used to develop population objectives for ducks at Tule Lake and Lower Klamath NWRs for each two-week interval between September 1 and April 15. Population objectives for each interval were based on survey counts from 1970 to 1979 and were equal to the 75^{th} percentile of these counts (Tables 5 and 6). The 75^{th} percentile rather than the mean was chosen because population numbers based on aerial surveys often are negatively biased (i.e., typically undercount the true number of birds) (Caughley 1977: 35) and because birds are often undetectable from the air (Pollock and Kendall 1987). A second reason for choosing the 75^{th} percentile was to achieve a greater probability that provided habitats would meet the needs of desired populations. By increasing the population objective to the 75^{th} percentile, habitats are increased and the needs of waterfowl would be met in greater than 50 percent of future years.

Migrating geese and Swans: Although duck population objectives were derived from the 1970s, population objectives for geese and swans were based on refuge counts from 1990 to 1999. Using data for goose populations from the 1990s is the same approach currently used in the IMWJV SONEC planning effort. Goose and swan populations in the Pacific Flyway have undergone major changes in size and distribution since the 1970s, so more recent counts were used to establish population objectives for Tule Lake and Lower Klamath NWRs. Aerial surveys every two weeks were used to develop population objectives for geese and swans at both refuges for each two-week interval between September 1 and April 15. Population objectives for each interval are equal to the 75^{th} percentile of these counts (Tables 5 and 6). The rationale for the 75^{th} percentile is the same as described for ducks.

Table 5. Waterfowl population objectives by date for Tule Lake National Wildlife Refuge, California (from Dugger et al. 2008). Population objectives were included for coots (based on 1970s aerial surveys), as coots compete with diving ducks and swans for food resources and must be considered in estimating habitat needs for waterfowl.

Date	Waterfowl Taxa or Guild[a]				
	Dabblers[b]	Divers[c]	Geese[d]	Swans	Coots
Sept 1	53,100	4,270	14,680	0	31,000
Sept 15	54,725	2,990	10,630	0	82,575
Oct 1	292,200	6,998	37,460	0	124,900
Oct 15	281,100	10,730	82,170	0	115,200
Nov 1	765,901	16,440	136,413	260	52,375
Nov 15	268,328	11,088	146,605	713	35,925
Dec 1	193,700	3,825	50,275	1,230	10,650
Dec 15	262,400	2,200	64,608	1,125	8,000
Jan 1	37,015	193	9,240	640	300
Jan 15	91,955	675	4,040	4,205	800
Feb 1	24,635	525	8,350	1,525	2,550
Feb 15	42,850	3,115	13,935	1,530	5,300
Mar 1	16,903	1,308	44,233	1,115	3,750
Mar 15	63,486	3,388	112,708	8	12,375
Apr 1	92,620	2,555	35,705	50	14,500
Apr 15	32,975	2,638	39,595	0	10,250

[a]Species combined into guilds based on foraging method and diet. Seventy-fifth percentiles calculated for either 1970-1979 (ducks and coots) or 1990-1999 (geese and swans); see methods in Dugger et al. (2008) for explanation.
[b]Dabblers include mallard, gadwall, northern pintail, green-winged teal, cinnamon teal, and northern shoveler,
[c]Divers include canvasback, redhead, ruddy duck, bufflehead, ring-necked duck, goldeneye, and scaup.
[d]Geese include Canada goose, cackling goose, greater white-fronted goose, lesser snow goose, Ross's goose.

Table 6. Waterfowl population objectives by date for Lower Klamath National Wildlife Refuge, California (from Dugger et al. 2008). Population objectives were included for coots (based on 1970s aerial surveys), as coots compete with diving ducks and swans for food resources and must be considered in estimating habitat needs for waterfowl.

Date	Waterfowl Taxa or Guild[a]				
	Dabblers[b]	Divers[c]	Geese[d]	Swans	Coots
Sept 1	213,521	2,270	7,640	0	28,000
Sept 15	219,869	1,791	5,820	0	33,250
Oct 1	401,738	3,708	51,610	0	52,863
Oct 15	597,010	7,385	36,095	0	59,925
Nov 1	597,536	6,313	34,160	1,545	23,625
Nov 15	487,361	5,783	46,855	3,193	15,925
Dec 1	372,560	1,250	19,475	930	19,500
Dec 15	198,118	855	12,488	1,398	5,500
Jan 1	10,594	160	7,430	2,490	540
Jan 15	27,171	305	12,990	7,211	550
Feb 1	77,714	800	11,431	14,043	1,750
Feb 15	223,459	2,175	56,580	14,960	8,350
Mar 1	148,414	1,560	66,248	18,995	4,850
Mar 15	203,306	1,600	80,433	3,186	11,000
Apr 1	96,775	3,600	49,880	0	45,000
Apr 15	83,339	2,020	70,185	0	16,475

[a]Species combined into guilds based on foraging method and diet. Means calculated for either 1970-1979 (ducks and coots) or 1990-1999 (geese and swans); see methods in Dugger et al. (2008) for explanation.
[b]Dabblers include mallard, gadwall, northern pintail, green-winged teal, cinnamon teal, and northern shoveler.
[c]Divers include canvasback, redhead, ruddy duck, bufflehead, ring-necked duck, goldeneye, and scaup.
[d]Geese include Canada goose, cackling goose, greater white-fronted goose, lesser snow goose, Ross's goose.

Breeding waterfowl: Population objectives for breeding waterfowl have not yet been established for the IMWJV. In the interim, for purposes of habitat management planning (for the CCP and habitat management plan [HMP]), breeding waterfowl objectives for the refuges will be similar to populations present in the 1970s (see Tables 3 and 4). As more information becomes available, detailed justification for breeding waterfowl and associated habitat objectives will be incorporated into habitat management planning documents.

Molting waterfowl: Habitat for molting waterfowl (particularly mallards breeding further south in California, see Yarris et al. (1994)) is an important function of both refuges. Unfortunately, very few late summer surveys have been conducted on Tule Lake and Lower Klamath NWRs to estimate current populations from which to develop population objectives. Population objectives for molting mallards could be achieved either through an extended period of survey work (5-10 years) or by assigning an objective based on a portion of the estimated breeding population of mallards in California. Over the last 20-plus years, the California Department of Fish and Game has conducted statewide waterfowl breeding population surveys each spring.

Bioenergetics modeling and current refuge habitat management

Using waterfowl population objectives in concert with food resources provided by different refuge habitats allows refuge managers and biologists to estimate the quantity and type of habitats needed to support population objectives. Thus, population objectives become thresholds toward which direct habitat management (quantity, quality, diversity, seasonality, location, etc.) is targeted. Inventory and monitoring of populations are then used to evaluate actual waterfowl populations and habitat use as part of an adaptive management process. This modeling approach assumes food availability is a key factor limiting waterfowl populations (Miller 1986, Conroy et al. 1989, Reinecke et al. 1989). During 2004 and 2005, the Service contracted with Oregon State University and Ducks Unlimited to evaluate current habitat management programs using the TRUEMET bioenergetics model (Dugger et al. 2008).

The TRUEMET model provides an estimate of population energy demand and population energy supply for specified time periods. Population energy demand is a function of period-specific population objectives and the daily energy requirements of individual birds during that period. Population energy supply is a function of the foraging habitats available and the biomass and nutritional quality of foods contained in these habitats. A comparison of energy supply vs. energy needs provides a measure of how well refuge habitats meet the energy needs of its target waterfowl populations. A more detailed description of the TRUEMET model is found in Dugger et al. (2008). There are seven explicit inputs required for each model run:

1. number of days or time periods being modeled,
2. population size for each waterfowl guild being modeled during each time period,
3. daily energy requirement of a single bird within a foraging guild,
4. acreage of each habitat available for each time period,
5. biomass of food in each habitat type on day one,
6. nutritional quality of each food type, and
7. percentage of a bird's daily energy needs met on site and the habitats or food types each guild uses to satisfy its daily energy requirements.

In using energetics modeling for Tule Lake and Lower Klamath NWRs, Dugger et al. (2008) evaluated current habitat management programs (habitats available in 2005) relative to waterfowl population objectives. In this modeling work, it was assumed that waterfowl would obtain 75 percent of their food resources on refuge (dabbling ducks and geese) or 100 percent of food resources on refuge in the case of diving ducks, gadwalls, and coots. Coots were included in the modeling work because of their relatively large numbers and because they compete for food resources with diving ducks and swans.

Lower Klamath NWR: Results of bioenergetics modeling presented in Dugger et al. (2008) indicated that current (2005) habitats provided on Lower Klamath NWR were adequate for population objectives for dabbling ducks (Fig. 13) and diving ducks and swans (Fig. 15) throughout the fall through spring period; however, refuge habitats were insufficient to support goose population objectives, as food resources were exhausted prior to March 1 (Fig. 14). One approach to modifying refuge habitats to provide for goose population objectives would require increasing standing grains by 500 acres and green browse by 2,000 acres (Dugger et al. 2008).

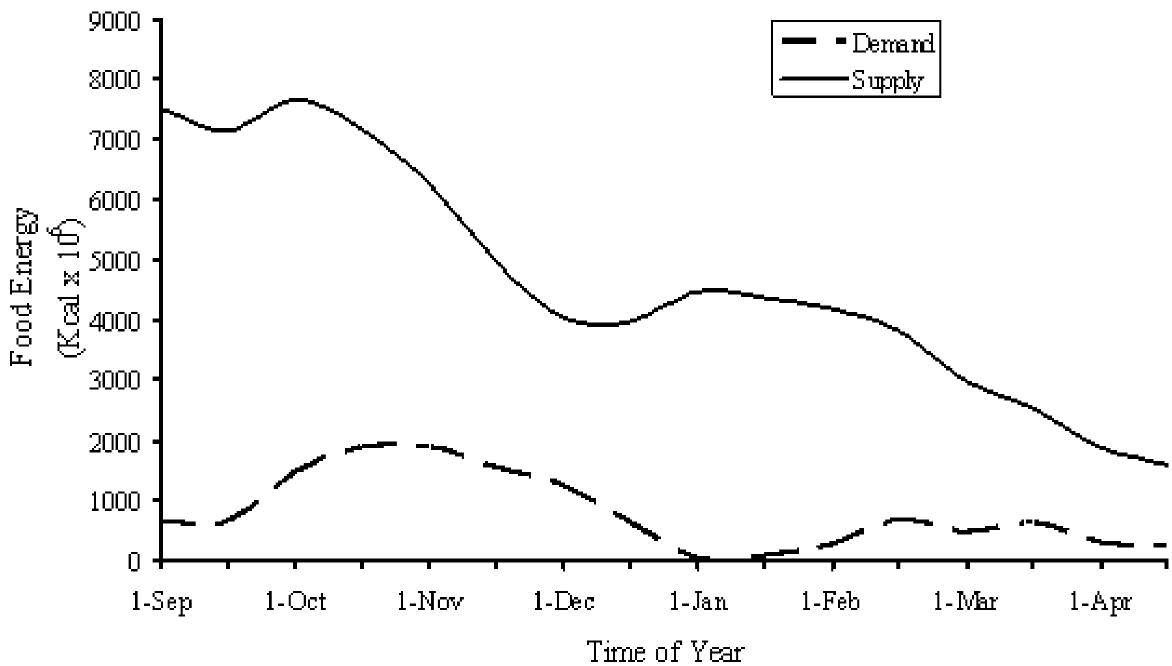

Fig. 13. Population energy demand vs. food energy supplies (simulated 2005 habitats) for dabbling ducks at Lower Klamath NWR relative to refuge population objectives (from Dugger et al. 2008). Food resources are insufficient to meet demand where the demand and supply curves cross.

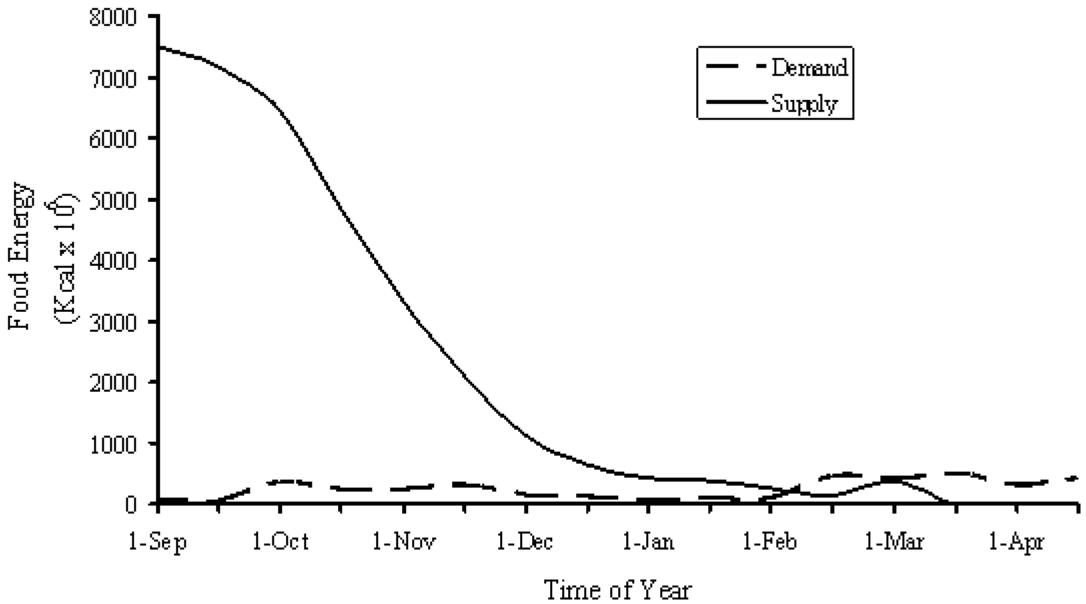

Fig. 14. Population energy demand vs. food energy supplies (simulated 2005 habitats) for geese at Lower Klamath NWR relative to refuge population objectives. Food resources are insufficient to meet demand where the demand and supply curves cross. (Dugger et al. 2008)

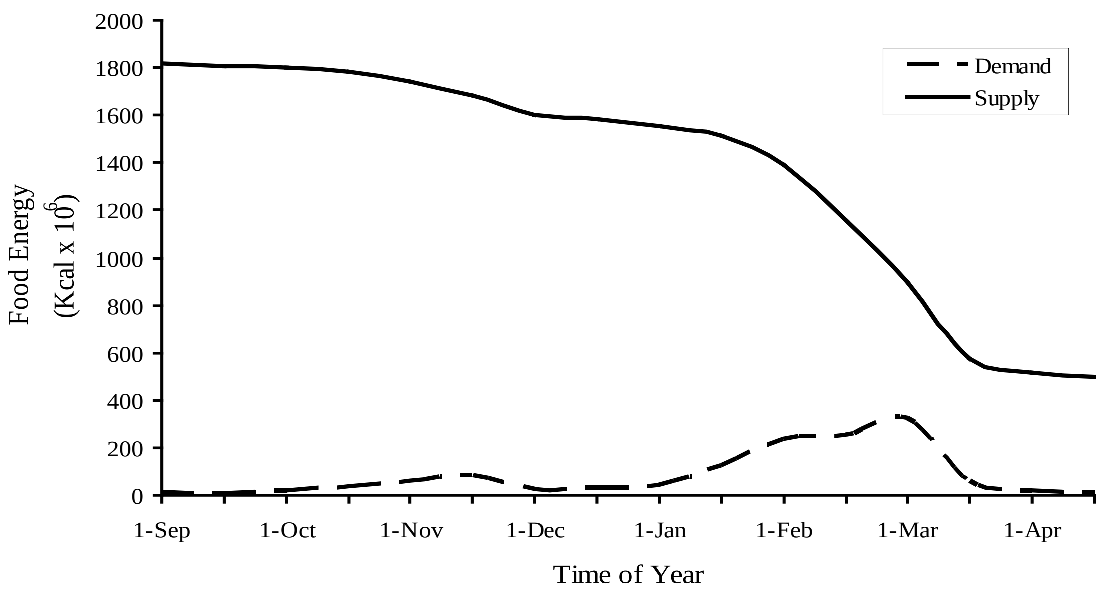

Fig. 15. Population energy demand vs. food energy supplies (simulated 2005 habitats) for diving ducks and swans at Lower Klamath NWR, relative to refuge population objectives. Food resources are insufficient to meet demand where the demand and supply curves cross. (Dugger et al. 2008)

Tule Lake NWR: The bioenergetics modeling for Tule Lake NWR indicated that agricultural food resources were inadequate to meet the foraging needs of dabbling ducks (Fig. 16) and geese (Fig. 17). Dabbling duck foods were exhausted by early fall, while goose food resources were exhausted by late winter. This shortage of foods for dabbling ducks and geese was primarily due to a lack of small grains on the refuge. Food resources for geese lasted longer into fall because potatoes are consumed by geese but not dabbling ducks. To rectify this situation, Dugger et al. (2008) estimated that 1,750 acres of additional unharvested grain would be required on the refuge. The modeling exercise revealed that food resources on Tule Lake NWR were adequate to meet population objectives for diving ducks and swans (Fig. 18).

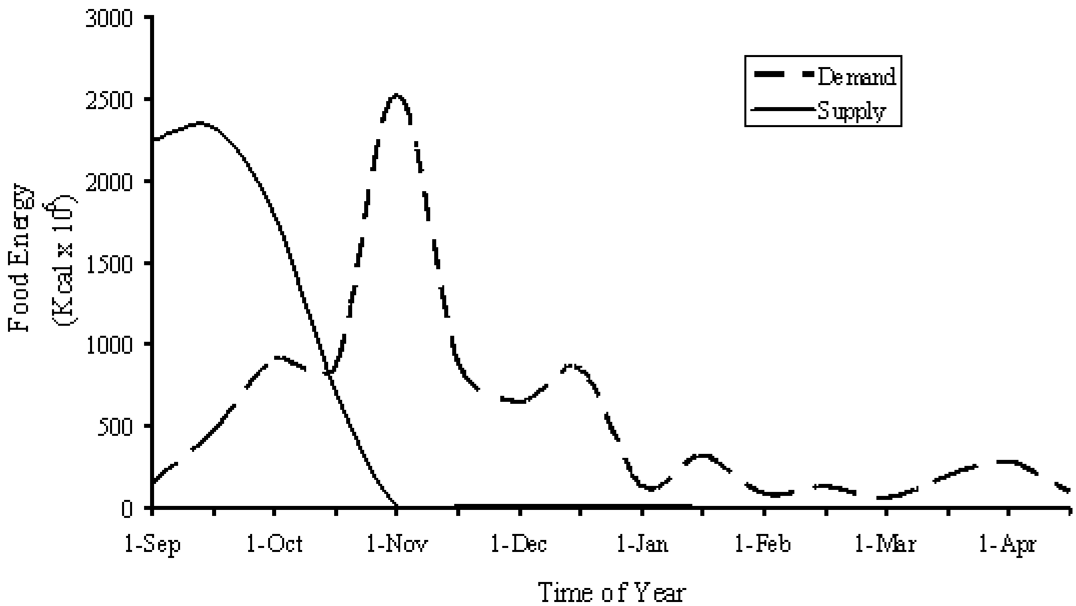

Fig. 16. Population energy demand vs. food energy supplies (simulated 2005 habitats) for dabbling ducks at Tule Lake NWR relative to refuge population objectives (from Dugger et al. 2008). Food resources are insufficient to meet demand where the demand and supply curves cross.

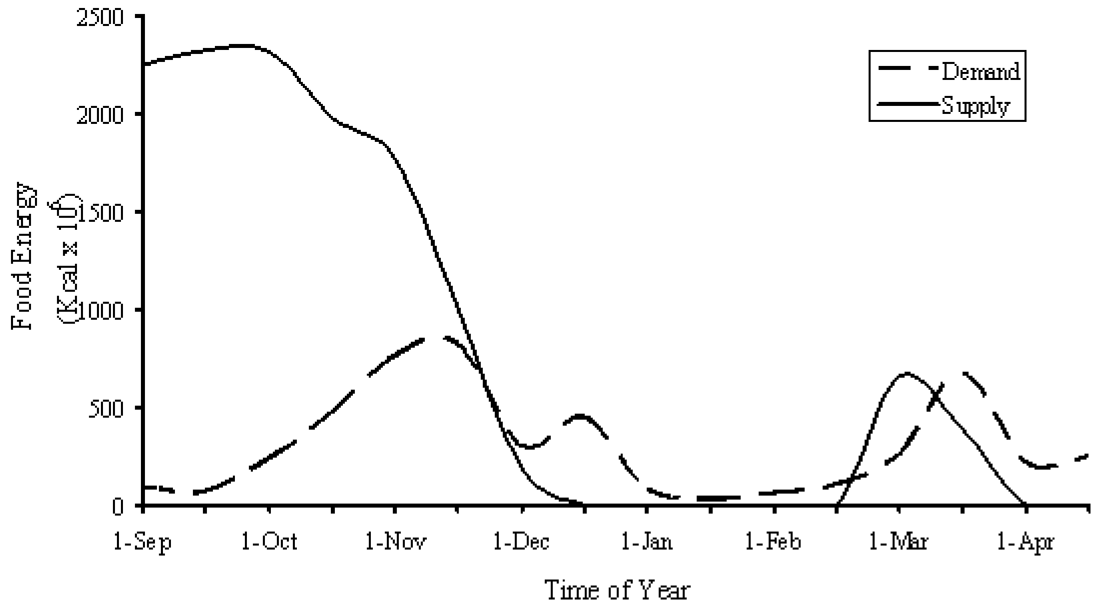

Fig. 17. Population energy demand vs. food energy supplies (simulated 2005 habitats) for geese at Tule Lake NWR relative to refuge population objectives (from Dugger et al. 2008). Food resources are insufficient to meet demand where the demand and supply curves cross.

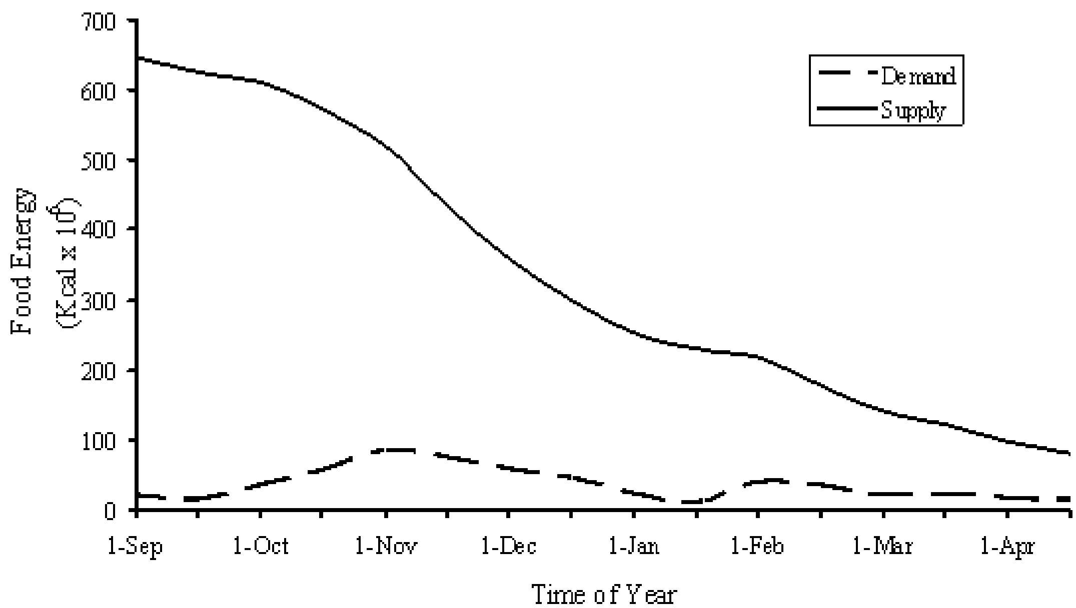

Fig. 18. Population energy demand vs. food energy supplies (simulated 2005 habitats) for diving ducks and swans at Tule Lake NWR relative to refuge population objectives (from Dugger et al. 2008). Food resources are insufficient to meet demand where the demand and supply curves cross.

Chapter VIII Summary and recommendations

Summary

The science and practice of both waterfowl management and agriculture have changed significantly since passage of the Kuchel Act. An improved understanding of waterfowl ecology, increasing demands by the public for a broader array of wildlife species provided, and increasingly scarce water resources to provide those values have necessitated changing management of the refuges. Within the broadly defined allowable crops in Section 4 of the Kuchel Act, cropping patterns have changed on the refuges primarily due to changing markets and improving agricultural technologies. In addition, the agricultural landscape adjacent to the refuges—as well as habitats available further south in the primary waterfowl wintering grounds in California— has also undergone modification. All of these factors have had impacts on waterfowl use of Tule Lake and Lower Klamath NWRs.

The Kuchel Act language and the congressional testimony leading to final enactment make clear that Congress intended that Tule Lake and Lower Klamath NWRs be managed for the major purpose of proper waterfowl management, but it is also evident that Congress intended that, to the extent consistent with proper waterfowl management, refuge agricultural leasing continue in specific areas of the refuges. Other refuge lands would be managed at the discretion of the Service. Analysis of waterfowl census data indicates that Tule Lake NWR has experienced significant declines in waterfowl use relative to Lower Klamath NWR, where the Kuchel Act allows greater flexibility in waterfowl habitat management.

Section 1 of the Kuchel Act makes clear that Congress' intent was to preserve existing waterfowl habitats on the Klamath Basin refuges and prevent waterfowl depredations on agricultural crops in the Pacific Flyway. This would occur through proper management of these refuges to provide adequate habitat to hold birds until crops had been harvested in the Central Valley (U.S. House of Representatives 1963). Thus, to comply with the Act, it is imperative that the Service restores lost waterfowl values at Tule Lake and Lower Klamath NWRs by developing strategies that improve and maintain those lands for waterfowl under the definition of "proper waterfowl management," while also continuing the refuge agricultural leasing program to the extent consistent with proper waterfowl management of those lands.

Moreover, the leased agricultural lands on the refuges should not be managed in isolation. They represent a component of the overall refuge habitat complex and must be used and/or modified as needed to provide the food and habitat needs in concert with other refuge habitats. This is especially important relative to the nutritional needs of waterfowl. Although agricultural crops contain an abundance of carbohydrates, they do not meet complete nutrition needs alone, because they have lower amounts of proteins, minerals, and key amino acids than other natural foods. In Lower Klamath NWR, agricultural lands currently consist of 27 percent of the overall refuge habitat matrix with a variety of other habitats in the land base. Thus waterfowl have the ability to utilize various habitats in Lower Klamath NWR that provide foods or other attributes, such as water and cover in addition to croplands. On Tule Lake NWR, refuge agricultural lands currently comprise approximately 55 percent of the overall refuge habitat mix, with the remaining habitat primarily in Sumps 1(A) and 1(B). The two sump areas do not provide the diversity and complexity of wetland habitats provided on Lower Klamath NWR, thus waterfowl currently have less option for utilizing diverse habitats on Tule Lake NWR.

Recommendations

The Service should implement a series of actions that will ensure that Tule Lake and Lower Klamath NWRs continue to be managed for wildlife conservation with the primary purpose of waterfowl management, as well as other Kuchel Act mandates, relevant Refuge System statutes, and applicable Department of Interior and Service policy. These actions include, but are not limited to the following:

- Under the Kuchel Act, the primary purpose of the Tule Lake and Lower Klamath NWRs is waterfowl management. The Kuchel Act also directs the Secretary to continue the "present pattern of leasing" and maximize lease revenues. Agricultural technologies and changing market conditions will alter cropping patterns on the leased lands in the future, as they have in the past. Thus, the Service should periodically evaluate the leasing program to ensure that sufficient agricultural foods are available to support spring and fall population objectives for geese and dabbling ducks. In future habitat management planning, Tule Lake and Lower Klamath NWR's leased land farming programs should be considered a component of the overall refuge habitat management program and be assigned to meeting specific waterfowl life history needs. Habitat management planning should be handled separately for each refuge.

- Refuge lands outside the leased lands, including wetlands, uplands, and agricultural lands, will also be managed for the primary purpose of waterfowl management. However, the broader "wildlife conservation" purposes also apply, subject to the primary purpose of waterfowl management. In implementing habitat management programs, the Service will use mandates from the 1997 Improvement Act, including Refuge System mission and Service policy related to biological integrity, diversity, and environmental health (601 FW 1). Consistent with the Kuchel Act, agricultural use will be fully considered in management of these "other refuge lands" when required to meet waterfowl management needs and/or the broader needs of wildlife conservation.

- Habitat management (620 FW1) and inventory and monitoring (701 FW 2) plans should be written or updated for both refuges. These documents are necessary to design, implement, and evaluate habitat management on both refuges.

- The National Wildlife Refuge System Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997, mandates that all uses on national wildlife refuges must be compatible with the purposes for which the refuge was established. For the purpose of the compatibility determination process, the consistency requirements in the Kuchel Act are deemed synonymous with the "compatibility" requirement in the Refuge Administration Act and the Refuge Improvement Act. Thus, compatibility determinations should be conducted for the refuges' farming programs consistent with the Refuge System Improvement Act and the Service's current compatibility policy (603 FW 2). Compatibility is defined by Federal law as, "…a wildlife-dependent recreational use or any other use of a refuge that, in the sound professional judgment of the Director, will not materially interfere with or detract from the fulfillment of the mission of the System or the purposes of the refuge" (16 U.S. C. 668ee(1)).

The Service's compatibility policy (603 FW 2) should be used to describe the stipulations required to ensure compatibility and consistency of the leased land farming program with waterfowl management and other Service and Interior policies as appropriate. These stipulations should be incorporated into lease contract language such that: (1) waterfowl food resources are provided during the appropriate time periods, and (2) specific management practices such as flooding during the waterfowl migration period, burning, interspersion of wetlands, and/or other provisions will increase the attractiveness, utilization, and interspersion of waterfowl use of the leased lands and make the agricultural program more consistent with waterfowl management. The leasing program will continue and revenues will be maximized, as required by the Kuchel Act, subject to the waterfowl management needs identified in habitat management planning and the compatibility determination process.

- This document provides a framework for developing alternatives in the CCP process, as well as guidance for preparation of habitat management plans for Lower Klamath and Tule Lake Refuges (see Service policy at 620 FW 1). From the more general HMP, year-specific habitat management plans are developed. Habitat management planning, utilizing the bioenergetics approach to conservation planning, provides the foundation for a successful, efficient, and well-coordinated use of refuge resources targeted to achieve refuge purposes and the Refuge System mission.

- In the late 1990s, the Service filed water rights claims in the Oregon adjudication. For both refuges, the Service filed claims for an irrigation right and claims for Federal reserved water rights. On March 7, 2013, Oregon Water Resources Department issued a Final Order of Determination. An irrigation right with a 1905 priority date, similar to other Project irrigators, was granted for croplands on both refuges (leased lands and cooperative farmed lands). For broader wetland purposes, a Federal reserved right was recognized with priority dates ranging from 1925 to 1964 (see Appendix 2). Due to legal issues and questions relative to these recently granted rights, it is likely that the Service will file exceptions with the Klamath County Circuit Court. But the junior priority of the Federal reserved water rights will not be contested.

- The availability of water is the key to providing agriculture and wetland waterfowl habitats. The Service can best meet the needs of all the guilds with reliable and full water delivery. The quantity of water and the timing of delivery determine which habitat types the Service can provide. The Service will manage these refuges according to habitat objectives outlined in the bioenergetics assessment. If less than full water delivery is available, the Service will calculate the proportion of habitat acreage objectives that can be met and prioritize which habitat types can be created to best manage for proper waterfowl management.

- Ongoing efforts among the Service, Reclamation, and TID to restore and enhance wetlands and other habitats on Tule Lake NWR should continue. Current examples include the Walking Wetlands/flood fallow program and Sumps 1A and 1B wetland enhancement projects. These projects have shown significant improvement in habitat conditions for wetland dependent wildlife species. In addition, the rotational nature of wetlands within the leased lands have significantly increased lease revenues, reduced fertilizer and pesticide use, and increased agricultural profitability.

Chapter IX Literature Cited

Abney, R.M. 1964. A comparative study of the past and present condition of Tule Lake. USDI Bureau of Sport Fisheries and Wildlife, Klamath Basin National Wildlife Refuges, Tulelake, Calif. 27 pp. + 26 exhibits.

Akins, G. J. 1970. The effects of land use and land management on the wetlands of the Upper Klamath Basin. M.S. Thesis, Western Washington State College, Bellingham. 121 pp.

Baldassarre, G. A., R. J. Whyte, E. E. Quinlin, and E. G. Bolen. 1983. Dynamics and quality of waste corn available to postbreeding waterfowl in Texas. Wildl. Soc. Bull. 11:25-31.

Baldassarre, G. A., and R. G. Bolen. 2006. Waterfowl ecology and management. 2nd ed., Krieger Publishing Co. , Malabar, Florida, 567pp.

Bartonek, J. C. 1968. Summer foods and feeding habits of diving ducks in Manitoba. Ph.D. Dissertation, Univ. of Wisconsin, Madison.

Bellrose, F. C. 1976. Ducks, geese, and swans of North America. Stackpole Books, Harrisburg, Pa. 544pp.

Bennett, J. B. 1958. Report on the homestead-lease controversy in the Lower Klamath and Tule Lake areas, Oregon and California. Report to the Secretary of Interior, January 31, 1958. 11pp.

Bolen, E. G. 2000. Waterfowl management: yesterday and tomorrow. J. Wildl. Manage. 64:323-335.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons, New York, NY.

Central Valley Joint Venture (CVJV). 2006. Central Valley Joint Venture Implementation Plan – Conserving Bird Habitat. U.S. Fish and Wildlife Service, Sacramento, CA.

Chura, N. J. 1961. Food availability and preferences of juvenile mallards. Transactions of the North American Wildlife And Natural Resources Conference 26:121-133.

Collias, N. E., and E. C. Collias. 1963. Selective feeding by wild ducklings of different species. Wilson Bulletin 75:6-14.

Conroy, M. J., G. R. Costanzo, and D. B. Stotts. 1989. Winter survival of female American black ducks on the Atlantic Coast. J. Wildl. Manage. 53:99-109.

Cottam, C. 1939. Food habits of North American diving ducks. U. S. Department of Agriculture Technical Bulletin 634.

Dugger, B. D., M. J. Petrie, and D. Mauser. 2008. A bioenergetic approach to conservation planning for waterfowl at Lower Klamath and Tule Lake National Wildlife Refuge. Report prepared for U.S. Fish and Wildlife Service, Klamath Basin National Wildlife Refuges. 110pp.

Fairchild, C. G., R. B. St. John, and D. W. Boyd. 1939. Five-year development program for the Clear Lake Migratory Bird Refuge, Upper Klamath Wildlife Refuge, Lower Klamath Refuge and the Tule Lake Wildlife Refuge. U.S. Department of Agriculture Bureau of Biological Survey, 152 pp. FWS.

Fleskes, J. P., and J. L. Yee. 2007. Waterfowl distribution and abundance during spring migration in Southern Oregon and Northeastern California. Western North American Naturalist 67: 409–428.

Fredrickson, L. H., and T. S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. U.S. Fish and Wildl. Serv. Resour. Publ. 148. 29pp.

Fredrickson, L.H. and F.A. Reid. 1990. Impacts on hydrologic alteration on management of freshwater wetlands. Pp 71-90 in: J.M. Sweeny, ed. Management of Dynamic Ecosystems. North Cent. Sect., The Wildl. Soc., West Lafayette, Ind.

Gilmer, D. S., M. R. Miller, R. D. Bauer, and J. R. LeDonne. 1982. California's Central Valley wintering waterfowl: concerns and challenges. Trans. N. Amer. Nat. Resour. Conf. 47:441-452.

Gilmer, D. S., Yee. J. L., Mauser, D. M., and J. L. Hainline. 2004. Waterfowl migration on Klamath Basin National Wildlife Refuges 1953-2001, U.S. Geological Survey, Biological Resources Discipline Biological Science Report USGS/BRD/BSR—2003-0004, 66pp.

Heitmeyer, M. E. 1988. Protein costs of the pre-basic molt of female mallards. Condor 90:263-266.

Ivey, G.L., and C.P. Herziger. 2006. Intermountain West Waterbird Conservation Plan, Version 1.2. A plan associated with the Waterbird Conservation for the Americas Initiative. Published by U.S. Fish and Wildlife Service, Pacific Region, Portland, Oregon, 205pp.

Janzen, D. H. 1962. Testimony of U.S. Fish and Wildlife Service Director Daniel Janzen regarding bill S. 1988 in hearings before the Subcommittee on Irrigation and Reclamation of the Committee on Interior and Insular Affairs, U.S. Senate, February 23, 1962.

Jensen, G. H., and J. E. Chattin. 1964. Western production areas, *in* Waterfowl tomorrow, J. P. Linduska, and A. L. Nelson, editors. U.S. Fish and Wildlife Service, 770pp.

Kadlec, J. A., and L. M. Smith 1989. The Great Basin marshes. Pages 451-474 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock, Texas. USA.

Krapu, G. L., and G. A. Swanson. 1975. Some nutritional aspects of reproduction in prairie nesting pintails. J. Wildl. Manage. 39:156-162.

Krapu, G. L., D. A. Brandt, and R. R. Cox, Jr. 2004. Less waste corn, more land in soybeans, and the switch to genetically modified crops: trends with important implications for wildlife management. Wildl. Soc. Bull. 32:127-136.

Laubhan, M. K., and L. H. Fredrickson. 1993. Integrated wetland management: concepts and opportunities. Trans. N. Amer. Wildl. Nat. Res. Conf. 58:323-334.

Martin, A. C., and F. M. Uhler. 1939. Food of game ducks in the United States and Canada. U.S. Department of Agriculture Technical Bulletin 634.

McAtee, W. L. 1911. Three important wild duck foods. U. S. Bureau of Biological Survey Circular 81.

McAtee, W. L. 1914. Five important wild-duck foods. U.S. Department of Agriculture Bulletin 58.

McAtee, W. L. 1915. Eleven important wild-duck foods. U.S. Department of Agriculture Bulletin 205.

Miller, M. R. 1986. Northern pintail body condition during wet and dry winters in the Sacramento Valley, California. Journal of Wildlife Management 50:189-198.

Miller, M. R., J. D. Garr, and P. S. Coates. 2010. Changes in the status of harvested rice fields in the Sacramento Valley, California: Implications for wintering waterfowl. Wetlands DOI:10.1007/s13157-010-0090-2.

North American Waterfowl Management Plan, Plan Committee. 1986. North American Waterfowl Management Plan: a strategy for cooperation. Canadian Wildlife Service, U. S. fish and Wildlife Service.

North American Waterfowl Management Plan. 1994. North American Waterfowl Management Plan: 1994 Update to the North American Waterfowl Management Plan. Canadian Wildlife Service, U. S. fish and Wildlife Service, and Minister of Environment, Natural Resources and Fisheries, Mexico.

North American Waterfowl Management Plan. 1998. North American Waterfowl Management Plan: Expanding the vision, 1998 update, North American Waterfowl Management Plan, Canadian Wildlife Service, U. S. fish and Wildlife Service, and Minister of Environment, Natural Resources and Fisheries, Mexico.

North American Waterfowl Management Plan. 2004. North American Waterfowl Management Plan 2004: Implementation Framework: Strengthening the Biological Foundation. Canadian Wildlife Service, U.S. Fish and Wildlife Service, Minister of Environment, Natural Resources and Fisheries, Mexico.

North American Waterfowl Management Plan. 2012a. North American Waterfowl Management Plan 2012: People conserving waterfowl and wetlands. Canadian Wildlife Service, U.S. Fish and Wildlife Service, Minister of Environment, Natural Resources and Fisheries, Mexico.

North American Waterfowl Management Plan. 2012b. NAWMP Action Plan: A companion document to the 2012 North American Waterfowl Management Plan. Canadian Wildlife

Service, U.S. Fish and Wildlife Service, Minister of Environment, Natural Resources and Fisheries, Mexico.

Oring, L. W., L. Neel, and K. E. Oring, Eds. 2000 (revised 2004). Intermountain West regional shorebird plan, version 1.0. Regional report of the U.S. Shorebird Conservation Plan. Manomet Center for Conservation Sciences, P.O. Box 1770, Manomet, MA 02345 (www.manomet.org).

Petrie, M. J., M. G. Brasher, G. J. Soulliere, J. M. Tirpak, D. B. Pool, and R. R. Reker. 2011. Guidelines for establishing joint venture waterfowl populations abundance objectives. North American Waterfowl Management Plan Science Support Team, Technical Report No. 2001-1. 34pp.

Pollock, K. H. and W. L. Kendall. 1987. Visibility bias in aerial surveys: A review of estimation procedures. Journal of Wildlife Management 51:502-510.

Reid, F. A., J. R. Kelley, Jr, T. S. Taylor, and L. H. Fredrickson. 1989. Upper Mississippi Valley wetlands – refuges and moist-soil impoundments. Pages 181-202 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock, Texas. USA.

Reinecke, K. J., R. M. Kaminski, D. J. Moorhead, J. D. Hodges, and J. R. Nassar. 1989. Mississippi Alluvial Valley. Pages 203-247 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock.

Ringleman, J. K. 1990. Managing agricultural foods for waterfowl. U.S. Fish and Wildlife Service, Waterfowl Management Handbook, Fish and Wildlife Leaflet 13.4.3, 4pp.

Sedinger, J. S. 1984. Protein and amino acid composition of tundra vegetation in relation to nutritional requirements of geese. J. Wildl. Manage. 48:1128-1136.

Shuford, W. D., D. L. Thomson, D. M. Mauser, and J. Beckstrand. 2006. Abundance and distribution of nongame waterbirds in the Klamath Basin of Oregon and California from comprehensive surveys in 2003 and 2004. Final Rep. to U.S. Fish and Wildlife Service, Klamath Basin National Wildlife Refuge, Tulelake, Calif. 87 pp.

Sugden, L. G. 1973. Feeding ecology of pintail, gadwall, American wigeon and lesser scaup ducklings. Canadian Wildlife Service Report Series 24.

Swanson, G. A., and J. C. Bartonek. 1970. Bias associated with food analysis in gizarrds of Blue-winged Teal. J. Wildl. Manage. 34:739-746.

Udall, S. L. 1962. Testimony of the Secretary of the Interior Stewart L. Udall regarding bill S. 1988 in hearings before the Subcommittee on Irrigation and Reclamation of the Committee on Interior and Insular Affairs, U.S. Senate, February 23, 1962.

U.S. Bureau of Reclamation. 1954. Report on the Upper Klamath Basin, Oregon-California. A comprehensive departmental report on the development of water and related resources. U.S. Bureau of Reclamation, Sacramento Regional Office, 443 pp.

U.S. Department of Interior. 1958. Secretary Seaton approves plan to settle long controversy over Tule-Klamath lands. Information Release, Office of the Secretary April 1, 1958, 2pp.

U.S. Fish and Wildlife Service. 1956a. Transmittal letter for the *Plan for wildlife use of federal lands in the Upper Klamath Basin, Oregon-California,* from John L. Farley, Director, to the Secretary of the Interior, dated April 20, 1956, 5pp.

U.S. Fish and Wildlife Service. 1956b. Plan for wildlife use of federal lands in the Upper Klamath Basin, Oregon-California. Report prepared by the U.S. Fish and Wildlife Service to the Secretary of Interior. 39pp.

U.S. Fish and Wildlife Service. National Wildlife Refuge System Mission and Goals and Refuge Purposes, 601 FW 1, www.fws.gov/policy/601fw1.html, accessed April 15, 2015.

U.S. Fish and Wildlife Service. Inventory and Monitoring in the National Wildlife Refuge System, 701 FW 2, www.fws.gov/policy/701fw2.html, accessed April 15, 2015.

U.S. House of Representatives. December 19, 1963. Promoting the Conservation of the Nation's Wildlife Resources on the Pacific Flyway in the Tule Lake, Lower Klamath, Upper Klamath, and Clear Lake National Wildlife Refuges in Oregon and California and Aiding in the Administration of the Klamath Reclamation Project, Report to accompany S. 793. The 88th Congress, 1st Session, House of Representatives Report No. 1072.

Weddell, B. J., K. L. Gray, and J. D. Foster. 1998. History and ecology of Lower Klamath, Tule Lake, Upper Klamath, and Klamath Forest National Wildlife Refuges, Oregon and California, Draft Report to U.S. Department of the Interior, Fish and Wildlife Service, Portland, Oregon. Draba Consulting, Pullman, WA. Contract Nos. 10181-5-1035 (PM), 10181-6-1199(EM), 10181-6-2148 (DS), 207 pp.

Weddell, B. J. 2000. Relationship between flows in the Klamath River and Lower Klamath Lake prior to 1910. Report prepared for U.S. Fish and Wildlife Service, Klamath Basin National Wildlife Refuges by Draba Consulting, Pullman, WA.,15 pp.

Yarris, G. S., M. R. McLandress, and A. E. H. Perkins. 1994. Molt migration of postbreeding female mallards from Suisun Marsh, California. Condor 96:36-45.

Appendix 1.

September 2, 1964 1771

KUCHEL ACT (PL 88-567)

WILDLIFE MANAGEMENT, KLAMATH PROJECT

An act to promote the conservation of the Nation's wildlife resources on the Pacific Flyway in the Tule Lake, Lower Klamath, Upper Klamath, and Clear Lake National Wildlife Refuges in Oregon and California and to aid in the administration of the Klamath Reclamation Project. (Act of September 2, 1964, Public Law 88-567, 78 Stat. 850)

Sec. 1. [Policy of the Congress.] - It is hereby declared to be the policy of the Congress to stabilize the ownership of the land in the Klamath Federal reclamation project, Oregon and California, as well as the administration and management of the Klamath Federal reclamation project and the Tule Lake National Wildlife Refuge, Lower Klamath National Wildlife Refuge, Upper Klamath National Wildlife Refuge, and Clear Lake National Wildlife Refuge, to preserve intact the necessary existing habitat for migratory waterfowl in this vital area of the Pacific Flyway, and to prevent depredations of migratory waterfowl on agricultural crops in the Pacific Coast States. (78 Stat. 850; 16 U.S.C. §695k)

Sec. 2. [Areas preserved for migratory waterfowl - Agricultural use.] - Notwithstanding any other provisions of law, all lands owned by the United States lying within the Executive order boundaries of the Tule Lake National Wildlife Refuge, the Lower Klamath National Wildlife Refuge, the Upper Klamath National Wildlife Refuge and the Clear Lake National Wildlife Refuge are hereby dedicated to wildlife conservation. Such lands shall be administered by the Secretary of the Interior for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith. Such lands shall not be opened to homestead entry. The following public lands shall also be included within the boundaries of the area dedicated to wildlife conservation, shall be administered by the Secretary of the Interior for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith, and shall not be opened to homestead entry: Hanks Marsh, and first form withdrawal lands (approximately one thousand four hundred and forty acres) in Klamath County, Oregon, lying adjacent to Upper Klamath National Wildlife Refuge; White Lake in Klamath County, Oregon, and Siskiyou County, California; and thirteen tracts of land in Siskiyou County, California, lettered as tracts 'A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I', 'J', 'K', 'L', and 'N' totaling approximately three thousand two hundred and ninety-two acres, and tract "P" in Modoc County, California, containing about ten acres, all as shown on plate 4 of the report entitled *"Plan for Wildlife Use of Federal Lands in the Upper Klamath Basin, Oregon-California,"* dated April 1956, prepared by the United States Fish and Wildlife Service. All the above lands shall remain permanently the property of the United States. (78 Stat. 850; 16 U.S.C. § 695l)

WILDLIFE MANAGEMENT, KLAMATH PROJECT

Explanatory Note

Klamath Project and Klamath Compact. All lands referred to in Section 2 above lie within, adjacent to or nearby the Klamath Federal reclamation project, Oregon-California. The project was authorized by the Secretary of the Interior, pursuant to the Reclamation Act of June 17, 1902, 32 Stat. 388, on May 15, 1905. The consent of Congress to the negotiation of a compact relating to the waters of the Klamath River by the States of Oregon and California was given by the Act of August 9, 1955, 69 Stat. 613. The consent of Congress to the resulting compact was given by the Act of August 30, 1957, 71 Stat. 497. Each of these acts appears herein in chronological order.

Sec. 3. [Payments to counties in lieu of taxes.] - Subject to conditions hereafter prescribed, and pursuant to such regulations as may be issued by the Secretary, 25 per centum of the net revenues collected during each fiscal year from the leasing of Klamath project reserved Federal lands within the Executive order boundaries of the Lower Klamath National Wildlife Refuge and the Tule Lake National Wildlife Refuge shall be paid annually by the Secretary, without further authorization for each full fiscal year after the date of this Act to the counties in which such refuges are located, such payments to be made on a pro rata basis to each county based upon the refuge acreage in each county: *Provided,* That the total annual payment per acre to each county shall not exceed 50 per centum of the average per acre tax levied on similar lands in private ownership in each county, as determined by the Secretary: *Provided further,* That no such payments shall be made which will reduce the credits or the payments to be made pursuant to contractual obligations of the United States with the Tulelake Irrigation District or the payments to the Klamath Drainage District as full reimbursement for the construction of irrigation facilities within said district, and that the priority of use of the total net revenues collected from the leasing of the lands described in this section shall be (1) to credit or pay from such revenues to the Tulelake Irrigation District the amounts already committed to such payment or credit; (2) to pay from such revenues to the Klamath Drainage District the sum of $197,315; and (3) to pay from such revenues to the counties the amounts prescribed by this section. (78 Stat. 850; 16 U.S.C. § 695m)

Sec. 4. [Leasing of reserved lands continued.] - The Secretary shall, consistent with proper waterfowl management, continue the present pattern of leasing the reserved lands of the Klamath Straits unit, the Southwest sump, the League of Nations unit, the Henzel lease, and the Frog Pond unit, all within the Executive order boundaries of the Lower Klamath and Tule Lake National Wildlife Refuges and shown in plate 4 of the report entitled *"Plan for Wildlife Use of Federal Lands in the Upper Klamath Basin, Oregon-California,"* dated April 1956. Leases for these lands shall be at a price or prices designed to obtain the maximum lease revenues. The leases shall provide for the growing of grain, forage, and soil-building crops, except that not more than 25 per centum of the total leased lands may be planted to row crops. All other reserved public lands included in section 2 of this Act shall continue to be managed by the Secretary for waterfowl purposes, including the growing of agricultural crops by direct planting and sharecrop agreements with local cooperators where necessary. (78 Stat. 851; 16 U.S.C. § 695m)

WILDLIFE MANAGEMENT, KLAMATH PROJECT

Sec. 5. [Areas not to be reduced.] - The areas of sumps 1(a) and 1(b) in the Klamath project lying within the Executive order boundaries of the Tule Lake National Wildlife Refuge shall not be reduced by diking or by any other construction to less than the existing thirteen thousand acres. (78 Stat. 851; 16 U.S.C. § 695o)

Sec. 6. [Water levels to be maintained.] - In carrying out the obligations of the United States under any migratory bird treaty, the Migratory Bird Treaty Act (40 Stat. 755), as amended or the Migratory Bird Conservation Act (45 Stat. 1222), as amended, waters under the control of the Secretary of the Interior shall be regulated, subject to valid existing rights, to maintain sump levels in the Tule Lake National Wildlife Refuge at levels established by regulations issued by the Secretary pursuant to the contract between the United States and the Tulelake Irrigation District, dated September 10, 1956, or any amendment thereof. Such regulations shall accommodate to the maximum extent practicable waterfowl management needs. (78 Stat. 851; 16 U.S.C. § 695p)

Explanatory Notes

Reference in the Text. The Migratory Bird Treaty Act of July 3, 1918, 40 Stat. 755, as amended, which is referred to in the text, does not appear herein. The Act is codified in 16 U.S.C. § 703, e*t seq*.

Reference in the Text. The Migratory Birds Conservation Act of February 18, 1929, 45 Stat. 1222, as amended, which is referred to in the text, does not appear herein. The Act is codified in 16 U.S.C. § 715, e*t seq.*

Sec. 7. [Clear Lake National Wildlife Refuge studies continued.] - The Secretary is hereby directed to complete studies that have been undertaken relating to the development of the water resources and waterfowl management potential of the Clear Lake National Wildlife Refuge. The results of such studies, when completed, and the recommendations of the Secretary shall be submitted to the Congress. (78 Stat. 851; 16 U.S.C. § 695q)

Sec. 8. [Regulations to implement Act.] - The Secretary may prescribe such regulations as may be necessary to carry out the provisions of this Act. (78 Stat. 851; 16 U.S.C. § 695r)

Explanatory Notes

Editor's Note, Annotations. Annotations of opinions are not included because none were found dealing primarily with the activities of the Bureau of Reclamation under this statute.

Legislative History. S. 793, Public Law 88-567 in the 88th Congress. Reported in Senate from Interior and Insular Affairs June 28, 1963; S. Rept. No. 341. Passed Senate July 15, 1963. Reported in House from Interior and Insular Affairs Dec. 19, 1963; H.R. Rept. No. 1072. Passed House, amended, Apr. 20, 1964. Senate asks for a conference Apr. 23, 1964. House agrees to a conference May 7, 1964. Conference report filed Aug. 17, 1964; H.R. Rept. No. 1820. House agrees to conference report Aug. 18, 1964. Senate agrees to conference report Aug. 19, 1964

Appendix 2.

Water rights for Lower Klamath and Tule Lake National Wildlife Refuges as determined by the Final Order of Determination issued March 7, 2013, by Oregon Water Resources Department.

Claim	Priority date	Location	Measurement Station	Quantity (A-F)	Period of use	Place of use
312	1905	LKNWR Irrigation	Station 48 Ady/Central Canal at K-River	35,000	Ady – Mar 1-Oct 31 Sta. 48-Feb 15-Nov 15	10,000 acres within 25,881.7 acres of refuge lands.
313	1925	LKNWR Fed Res Right	Station 48 Ady/Central Canal	108,229.4	Jan 1-Dec 31	Most refuge lands
314	1964	LKNWR Fed Res Right	Station 48	3,680.1	Jan 1-Dec 31	Primarily White Lake and some small P-canal parcels.
315	1944	LKNWR Fed Res Right	Station 48 Ady/Central Canal	1,141.7	Jan 1-Dec 31	Units 9b/c/g area
316	1949	LKNWR Fed Res Right	Station 48 Ady/Central Canal	87.6	Jan 1-Dec 31	Small parcel SE area of Refuge
317	1905	TLNWR Irrigation	Station 48	49,902.3	Feb 15-Nov 15	16,000 acres within area of 17,967.3 ac (Sumps 2-3 lease and coop lands)
318	1928	TLNWR Fed Res Right	Station 48	31,480.9	Jan 1-Dec 31	8,168.8 ac, Sump 1A
319	1932	TLNWR Fed Res Right	Station 48	2,874.7	Jan 1-Dec 31	766.4 ac, within Sump 1A
320	1936	TLNWR Fed Res Right	Station 48	66,205.8	Jan 1-Dec 31	21,867.7 ac, Sump 1B, and Sumps 2-3

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Appendix N – A Bioenergetic Approach to Conservation Planning for Waterfowl at Lower Klamath and Tule Lake National Wildlife Refuges

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A BIOENERGETIC APPROACH TO CONSERVATION PLANNING FOR WATERFOWL AT LOWER KLAMATH AND TULE LAKE NATIONAL WILDLIFE REFUGE

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U.S. Department of the Interior
Fish and Wildlife Service
Klamath Basin Refuges
Tule Lake, CA

1 April 2008

EXECUTIVE SUMMARY

Lower Klamath and Tule Lake National Wildlife Refuges (hereafter abbreviated LKNWR and TLNWR, respectively) are managed by the U.S. Fish and Wildlife Service (Service) as part of the Klamath Basin NWR Complex. The Klamath Basin is recognized as a region of continental significance to North American waterfowl populations (NAWMP Plan Committee 2004). Conservation and management of waterfowl habitats on both refuges is dependent on the availability of water. Increasing competition within the Klamath Basin for water requires that the Service articulate habitat requirements and water needs to support objective waterfowl populations. This report summarizes empirical research and modeling activities designed to assist the Service in efforts to develop biologically sound management plans for waterfowl during fall through spring, the period when waterfowl use is highest on LKNWR and TLNWR. This work is part of an overall Strategic Habitat Conservation approach being developed to design, implement and monitor management actions on both refuges. Our specific objectives were to: 1) use waterfowl survey data to establish spring and fall waterfowl population objectives for TLNWR and LKNWR; 2) estimate biomass and metabolizable energy of key foods in permanent and seasonal wetlands at TLNWR and LKNWR; 3) evaluate current refuge habitat management practices relative to waterfowl food energy needs for each refuge; 4) identify foraging habitat deficiencies that may exist for each refuge; and 5) evaluate a range of potential management alternatives for meeting waterfowl food energy needs.

In Chapter 2, we used bi-weekly aerial counts of waterfowl populations from 1 September to 15 April to characterize waterfowl migration chronology, population size, and species composition and to contrast waterfowl populations between refuges and two time periods (1970-1979 and 1990-1999). We summarized survey data by partitioning waterfowl species in to five guilds based on foraging method and diet (dabbling ducks, diving ducks, geese, swans, and coots) and calculated the 10-year mean population estimate for each guild, during each survey for each block of years (1970s vs. 1990s). Finally, we used the survey data to establish guild-specific population objectives. Trends in waterfowl abundance between time periods and seasons varied considerably between refuges. Total mean counts at LKNWR increased from the 1970s to 1990s,

whereas counts at TLNWR have declined since the 1970s. The most striking change has occurred in dabbler and goose abundance. At LKNWR dabbler and goose use has remained constant in fall and increased in spring; in contrast, dabblers at TLNWR in fall have declined from a mean of nearly 500,000 birds in 1970s to less than 100,000 birds in the 1990s. Goose counts at TLNWR declined during fall from a mean peak of 375,000 in the 1970s to just over 120,000 in the 1990s, peak spring counts declined by over 50% during the same period. Swan counts at LKNWR during winter and spring have increased from the 1970s to 1990s. We used data collected during 1970–1979 to establish dabbling duck, diving duck, and coot population objectives and data from 1990-1999 to establish goose and swan population objectives for conservation planning.

In Chapter 3, we report on field work designed to: 1) estimate moist-soil seed biomass in early v. late seasonal wetlands; 2) estimate tuber and green foliage produced by submerged aquatic vegetation in permanent wetlands; 3) estimate the biomass of macroinvertebrates in seasonal wetlands during spring; 4) estimate the true metabolizable energy value for the seeds of four plants commonly eaten by ducks in the Klamath Basin; and 5) estimate energy production in seasonal and permanent wetland habitats at LKNWR and TLNWR. We sampled foods in 3 of 5 seasonal wetland management units on TLNWR, 9 of 20 seasonal wetlands on LKNWR (representing 4 early and 5 late successional units), 1 permanent wetland at TLNWR 2 of 9 permanent wetlands at LKNWR.

Mean seed biomass estimates ranged from 241 kg/ha in unit 10B to 1,425 kg/ha in unit 5 (Tables 3-3 and 3-4); the mean for early and late successional wetlands was 1,002 ± 159 kg/ha and 584 ± 91 kg/ha, respectively. The composite TME value was 2.38 kcal/g for early successional wetlands and 1.59 kcal/g for late successional wetlands. Mean biomass for tubers was 229.7 ± 55.7 kg/ha in fall, higher at Lower Klamath than Tule Lake (Table 3-5). There was no difference in mean invertebrate biomass by wetland type ($F_{2,10} = 3.52$, $P = 0.07$). Cladocerans, Copepods, Oligochaetes, and Chironomids were the numerically dominant macroinvertebrate taxa in all wetlands (Appendix B).

We conducted controlled feeding trials using game-farm male mallards to determine the True Metabolizable Energy value for the seeds of three native species and one invasive exotic. TME_N values differed among seed species ($F_{3,20} = 80.5$, $P < 0.0001$), being highest for lamb's quarters (2.52 kcal/g), followed by perennial pepperweed (1.31 kcal/g), alkali bulrush (0.65 kcal/g), and spike rush (0.50 kcal/g). The results from this work have been published in a peer-reviewed science journal.

In chapter 4, we incorporated data from Chapter's 2 and 3 into a bioenergetic model and used the model to evaluate current refuge management practices relative to waterfowl food energy needs for each refuge, identify foraging habitat deficiencies that may exist for each refuge, and evaluate potential habitat management alternatives for meeting waterfowl food energy needs. Our modeling indicated deficiencies in energy supplies for one or more guild at each refuge. Current habitats at both refuges were sufficient to meet the energy needs for target populations of swans and diving ducks. LKNWR habitats were also sufficient for meeting the needs of dabbling ducks. However, assuming waterfowl obtain 75% of foods on-Refuge, LKNWR could not meet goose population objectives in spring, and habitats at TLNWR did not meet the needs of dabbling ducks in fall or geese in spring.

We then modeled several alternate management scenarios for each refuge to explore possible options for eliminating habitat deficits. Our options were not exhaustive; rather they provided examples of how a bioenergetic model can be used to explore management options. Our results indicate a variety of habitat scenarios can meet the energy needs of migrating and wintering waterfowl, thus providing flexibility to refuge managers as they consider the broader suite of wildlife species that depend on both refuges to meet their life-cycle needs. We hope our model provides the framework for objectively considering how potential land use changes might impact wintering and migrating waterfowl at both Tule Lake and Lower Klamath Lake National Wildlife Refuges.

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1. INTRODUCTION

Lower Klamath and Tule Lake National Wildlife Refuges (hereafter abbreviated LKNWR and TLNWR, respectively) are managed by the U.S. Fish and Wildlife Service (Service) as part of the Klamath Basin NWR Complex. Of the Complex's six NWRs, Tule Lake and Lower Klamath NWRs support greater than 80% of the Complex's waterfowl populations and, during a typical year, support greater than 50% of the waterfowl in the Upper Klamath Basin. Peak populations of waterfowl approach two million birds in both fall and spring. The Klamath Basin is recognized as a region of continental significance to North American waterfowl conservation (NAWMP Plan Committee 2004). As the two most important wetland habitats in the Basin, TLNWR and LKNWR are among the most important waterfowl migration staging areas in the Pacific Flyway.

Increasing competition within the Klamath Basin for limited water supplies and the ongoing water rights adjudication by the state of Oregon requires that the Service be able to articulate habitat requirements and water needs. From an ecological perspective, the Service wants to establish waterfowl population objectives, and estimate habitats needed to achieve these objectives (e.g., CVJV 2006). Such a plan would guide site specific management and place refuge population and habitat objectives within the larger context of regional and continental waterfowl management objectives as established by the North American Waterfowl Management Plan (NAWMP 1986). Ideally the refuge planning exercise should be flexible enough to permit an objective comparison among a suite of potential habitat management alternatives. This report summarizes empirical research and modeling activities designed to assist the Service in efforts to develop biologically sound management plans for waterfowl during fall through spring, the period when waterfowl use is highest on LKNWR and TLNWR. This work represents the biological planning phase of a Strategic Habitat Conservation Framework being developed for managing habitats at both LKNWR and TLNWR (National Ecological Assessment Team 2006).

Our Approach

Conservation planning for migrating and wintering waterfowl is based on the fundamental premise that food is the resource limiting population performance. Poor habitat conditions reduce food abundance, which can decrease body mass or nutrient reserves (Delnicki and Reinecke 1986, Krapu et al. 2004), increase movements and vulnerability to hunting mortality (Hepp et al. 1986), increase predation risk by altering foraging methods and vigilance behavior (Guillemain et al. 2000*a*, Fritz et al. 2002), and ultimately decrease survival and breeding potential (Krapu 1981, Kaminski and Gluesing 1987, Raveling and Heitmeyer 1989, Goss-Custard et al. 2006). Recent research has documented food depletion on migration and wintering areas in North America (Rutka 2004, Naylor 2002, Krapu et al. 2004, Greer et al. 2007) consistent with the hypothesis that food is limiting, and other work has documented shifts in bird distribution within and among seasons in response to food depletion (Tubbs and Tubbs 1983, Lovvorn and Baldwin 1986, Sutherland and Allport 1994, Nolet et al. 2006). Thus, for planning, understanding food abundance is one key step towards estimating habitat carrying capacity (Gill et al. 1996, Miller and Newton 1999, Nolet et al. 2006) and understanding the movement, distribution, and habitat use of wintering and migrating waterfowl (Sutherland and Allport 1994, Percival et al. 1996, Guillemain et al. 2000*b*, Nolet et al. 2001, Stillman et al. 2005, Klaassen et al. 2007).

The most effective tool for using food (i.e., energy) in conservation planning is a bioenergetic model (Sutherland 1996); most habitat joint ventures established under the North American Waterfowl Management Plan (NAWMP) use bioenergetic models to estimate habitat objectives for migrating and wintering waterfowl (e.g., Central Valley joint Venture Implementation Plan 2006). Bioenergetic models rely on four basic types of input data: daily bird energy needs and time-specific population objectives are used to calculate population energy demands, while habitat quantity (how many hectares) and quality (the nutritional value of foods in each habitat type) are used to calculate energy supplies. For LKNWR and TLNWR, detailed information on habitat composition and bird abundance is available from the Service; estimates of daily bird energy needs can be derived from metabolic equations that relate energy needs to body size and activity patterns (Aschoff & Pohl 1970, Miller and Eadie 2006). Data on the nutritional value of most agricultural foods are available from the literature; data for some, but not all, natural foods occurring in wetlands on LKNWR and TLNWR are also available in the literature (Hoffman and Bookhout 1985, Petrie et al. 1997, Checkett et al. 2002). Estimates of habitat-specific food availability are lacking. We sampled habitats and conducted controlled feeding experiments to gather information needed to populate a bioenergetic model. We then used that model to evaluate past, current, and alternative habitat management scenarios for waterfowl at LKNWR and TLNWR.

Objectives

The specific objectives of this report include:

1. Use waterfowl survey data to establish spring and fall waterfowl population objectives for TLNWR and LKNWR.
2. Estimate biomass and metabolizable energy of key foods in permanent and seasonal wetlands at TLNWR and LKNWR.
3. Evaluate current refuge habitat management practices relative to waterfowl food energy needs for each refuge.
4. Identify foraging habitat deficiencies that may exist for each refuge.
5. Evaluate a range of potential management alternatives for meeting waterfowl food energy needs.

The remainder of this report consists of three chapters. Chapter 2 uses data from aerial surveys of waterfowl populations to summarize population trends for TLNWR and LKNWR and develop waterfowl population objectives for both refuges (Objective 1). Chapter 3 reports on field sampling to estimate the abundance of key foods in wetland habitats and controlled feeding experiments to estimate metabolizable energy for select waterfowl foods (Objective 2). Chapter 4 introduces the bioenergetic model and uses data from Chapters 2 and 3 to evaluate past and current habitat conditions and explore management alternatives for meeting waterfowl food energy needs at TLNWR and LKNWR (Objectives 3-5).

2. WATERFOWL POPULATION TRENDS AND MANAGEMENT OBJECTIVES FOR LOWER KLAMATH AND TULE LAKE NATIONAL WILDLIFE REFUGES

Population objectives for TLNWR and LKNWR are required to establish habitat goals and to evaluate management alternatives using a bioenergetic model. The North American Waterfowl Management Plan (NAWMP) has developed continental population objectives for North American duck species based on environmental conditions and breeding waterfowl numbers from 1970-1979 (North American Waterfowl Management Plan 1986). Most regional Joint Ventures derive population objectives by stepping down continental objectives based on the number and distribution of waterfowl during the 1970's (Central Valley Joint Venture 2006). This approach is less suitable for areas at smaller scales like a specific national wildlife refuge; however, site-specific survey data from the period of years used to generate continental objectives can be used to derive site-specific population objectives that are linked to NAWMP goals. In this chapter, we use data from aerial surveys for both LKNWR and TLNWR to examine population trends and establish population objectives.

Methods

We used waterfowl surveys conducted once every two weeks from 1 September to 15 April to characterize waterfowl migration chronology, population size, and species composition and to contrast waterfowl populations between refuges and two groups of years 1970-1979 and 1990-1999. Aerial surveys were flown from a low flying airplane and birds were identified to species. Survey methods are described by Gilmer et al. (2004). We used data collected during 1970 – 1979 to establish duck and coot population objectives and link duck objectives at TLNWR and LKNWR to the NAWMP. Goose and swan populations have undergone major changes in size and distribution across North America and within the Klamath Basin since the 1970's. While these changes, in part, may be influenced by habitat management at TLNWR and LKNWR they also reflect larger changes within the Pacific Flyway. For example, Cackling Geese (*Branta hutchinsii minima*) no longer use the Klamath Basin in fall and it is unlikely that any habitat management on the refuge can reverse this trend (Pacific Flyway Council

1999). Thus, it made no sense to use data from the 1970's to establish population objectives for geese and swans at either refuge. Rather, we used survey data from 1990-1999 to establish goose and swan population objectives for 24 August to 22 April the period that encompasses the non-breeding season.

We summarized survey data by assigning species to one of four waterfowl guilds based on foraging method and diet; 1) dabbling ducks, 2) diving ducks, 3) geese, and 4) swans. We summarized data for American coot (*Fulica americana*) separate from the other waterfowl. Dabbling ducks included Northern Pintail (*Anas acuta*), Mallard (*A. platyrhynchos*), American Wigeon (*A. americana*), Northern Shoveler (*A. clypeata*), Green-winged Teal (*A. crecca*), Cinnamon Teal (*A. cyanoptera*), and Gadwall (*A. strepera*). Diving ducks included Canvasback (*Aythya valisneria*), Redhead (*A. americana*), and Ring-necked Duck (*A. collaris*). Although TLNWR and LKNWR support large numbers of Ruddy Ducks (*Oxyura jamaicensis*), Bufflehead (*Bucephala albeola*), and scaup (Aythya sp.), we did not establish population objectives for these species because we lacked information on the foods consumed by these birds. Geese included Lesser Snow Geese (*Chen caerulescens*), Greater White-fronted Geese (*Anser albifrons*), Cackling Geese, and Canada Geese (*B. canadensis*). We then calculated the 10-year mean population estimate for each guild for each date period. We graphed means to compare guild abundance among time periods and refuges.

We examined population trends at TLNWR and LKNWR to gain insight into how waterfowl use of the refuges has changed and help identify management alternatives that should be considered in the bioenergetic modeling process. We calculated the mean and 75% percentile count for each two-week interval. We graphed trends by date and defined seasons (when using those terms in the text) as 24 August through 22 November (fall), 23 November and 22 January (winter), 23 January through 22 April (spring). These date blocks do not match the calendar seasons, but closely corresponds to phases of the annual life cycle of waterfowl using the Klamath Basin (fall migration, wintering, and spring migration).

We also examined changes in the species composition of the dabbling duck and diving duck guilds among seasons (e.g. fall vs. spring) and among time periods (1970's vs. 1990's). To estimate the relative abundance of each species in a foraging guild, we first calculated total waterfowl use days for each two-week interval centered on a survey. Waterfowl use days were calculated as total birds counted multiplied by 14 (one week on either side of the survey). For example, if the total waterfowl count on a survey was 100,000 birds, then total waterfowl use days for that two-week period = 100,000*14 = 1,400,000. If Mallards comprised 20% of all dabbling ducks counted, we assigned 300,000 waterfowl days to mallards in that interval (0.2 * 1,500,000 = 300,000 mallard days). We calculated use days for all species for each two-week interval included in a season and summed the results across intervals. For example, the fall season included all two-week intervals between 24 August and 22 November. If the sum of all waterfowl days for each of these intervals equals ten million, and the sum of all mallard days in these intervals equals two million, then mallards were assumed to make up 20% of the dabbling duck guild during the fall season.

Finally, we used the survey data to establish guild-specific population objectives. Waterfowl population objectives must consider both abundance and timing of use; consequently, we used count data for each bi-weekly survey and set the population objective for each guild during each date interval as the 75th percentile of the ten counts. We chose the 75th percentile, versus the mean, for several reasons. Philosophically, we feel it is not sound waterfowl management to establish habitat objectives (habitat needs are based on population objectives) that would meet waterfowl food needs in only 50% of years. Practically, population estimates from aerial count data are negatively biased (Caughley 1977: 35) because survey methodology did not correct for detectability (Pollock and Kendall 1987), and our estimates of food production in refuge habitats (Chapter 3) may not be met in all years; during years of relatively low food production our modeling would over estimate habitat carrying capacity.

Results

<u>Population trends</u>

LKNWR and TLNWR combined.— Patterns in waterfowl abundance between the 1970s and 1990s and changes in seasonal use patterns differed among bird guilds. The total number of dabbling ducks using TLNWR and LKNWR in fall and winter was similar between the 1970s and 1990s, but seasonal use was slightly different. Dabbler abundance in fall has declined since the 1970s while spring use has increased (Figure 2-

1). Use days for diving ducks were higher in the 1990's during both fall and spring (Figure 2-2). Swan use was similar in fall, a period when relatively few birds use the refuges, but swan use days in winter and spring were higher during the 1990s than 1970s (Figure 2-3). Total goose use days declined from the 1970s to 1990s with most of the decline occurring during fall (Figure 2-4). Total coot use days were lower during the 1970s with all declines attributable to decreased use in fall (Figure 2-5).

Population trends by refuge.-- Trends in waterfowl abundance between time periods and seasons varied considerably between refuges. Total mean counts at LKNWR increased from the 1970s to 1990s, whereas counts at TLNWR have declined since the 1970s. The most striking change has occurred in dabbler and goose abundance. At LKNWR dabbler and goose use has remained constant in fall and increased in spring; in contrast, dabbler counts at TLNWR in fall have declined from a mean of nearly 500,000 birds in 1970s to less than 100,000 birds in the 1990s. Goose counts at TLNWR declined during fall from a mean peak of 375,000 in the 1970s to just over 120,000 in the 1990s, peak spring counts declined by over 50% during the same period (Figures 2-6 and 2-7). Trends in diver use were similar between refuges with higher counts during fall and spring in the 1990s (Figure 2-8). Swan counts at LKNWR during winter and spring have increased from the 1970s to 1990s and remained unchanged at TLNWR (Figure 2-9). Coot counts at LKNWR were similar between the 1970s to 1990s, but coot counts at TLNWR declined during the same period (Figure 2-10).

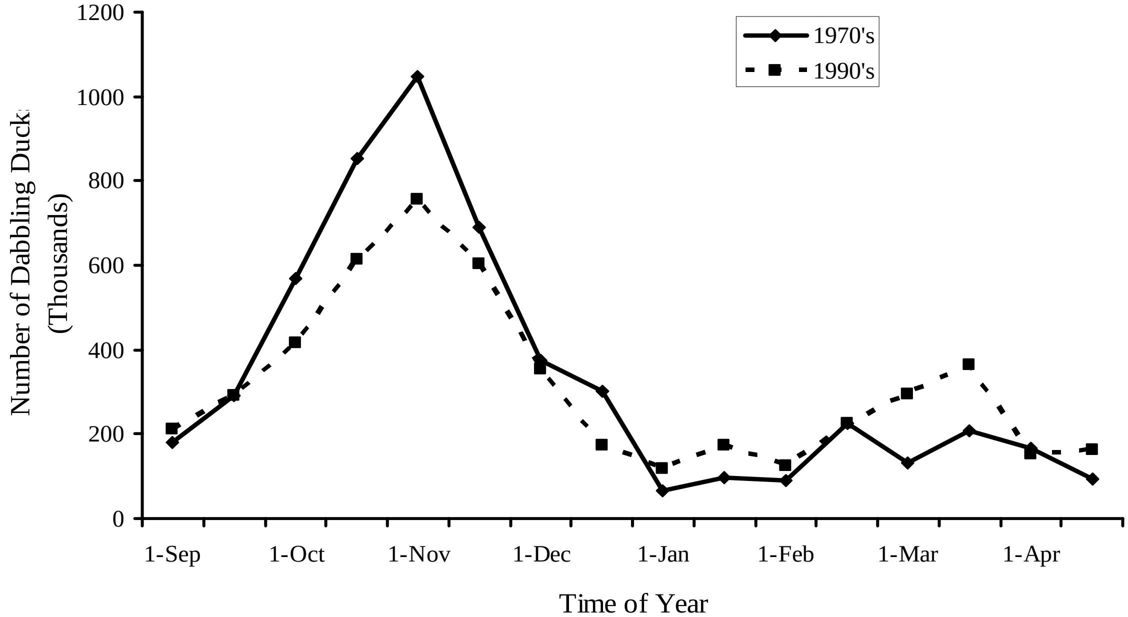


Figure 2-1. Mean counts of dabbling ducks at Tule Lake and Lower Klamath National Wildlife Refuges in the 1970’s (1970-1979) and 1990’s (1990 -1999) determined from aerial surveys.

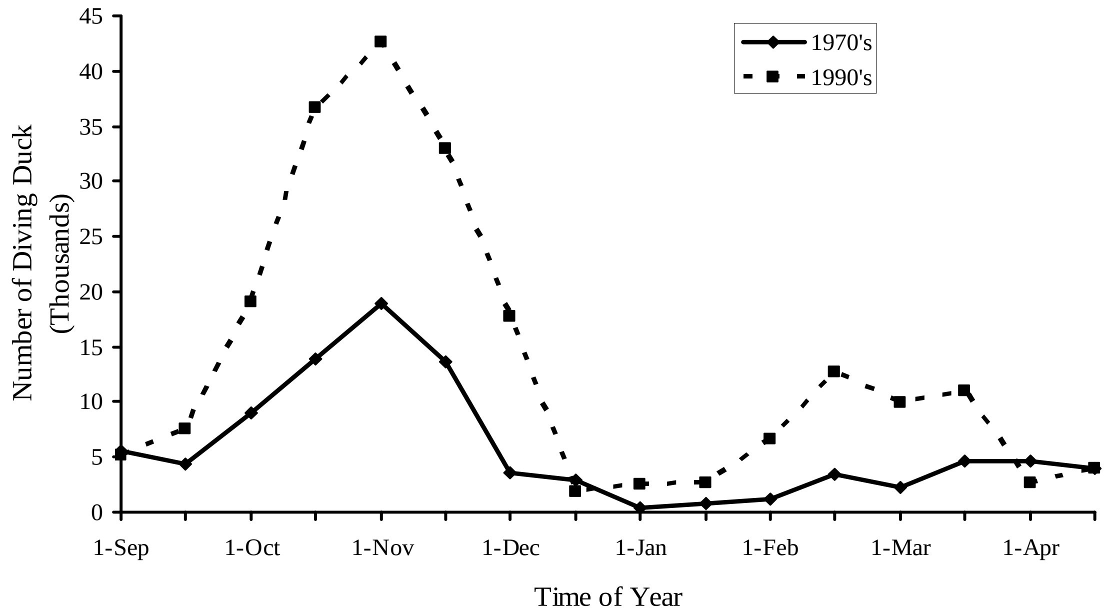


Figure 2-2. Mean counts of diving ducks at Tule Lake and Lower Klamath National Wildlife Refuges in the 1970’s (1970-1979) and 1990’s (1990 -1999) determined from aerial surveys.

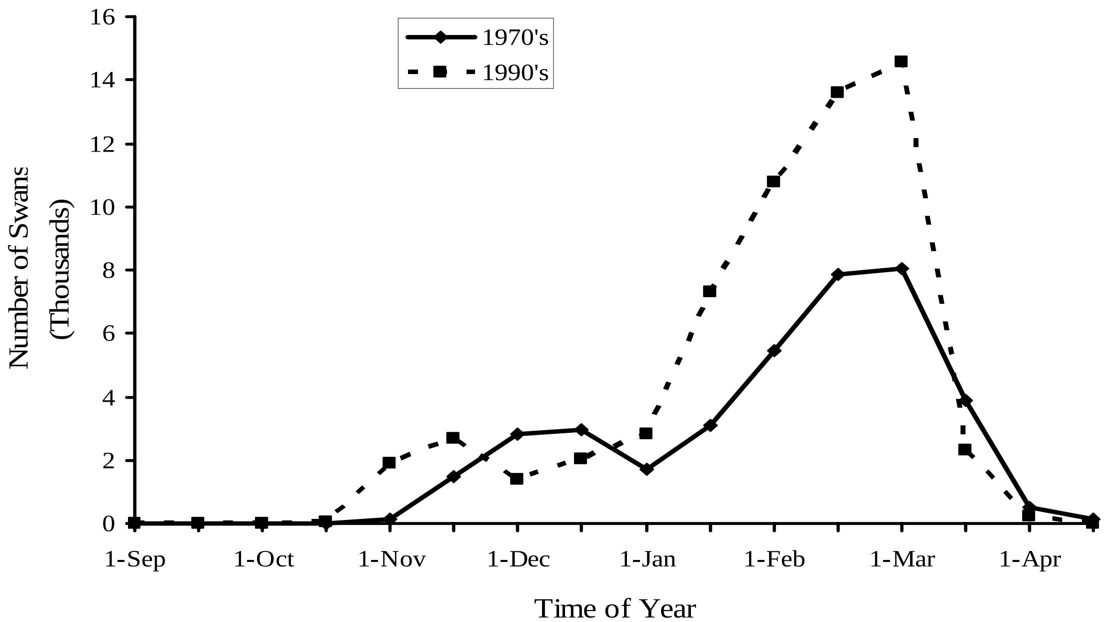


Figure 2-3. Mean counts of swans at Tule Lake and Lower Klamath National Wildlife Refuges in the 1970’s (1970-1979) and 1990’s (1990 -1999) determined from aerial surveys.

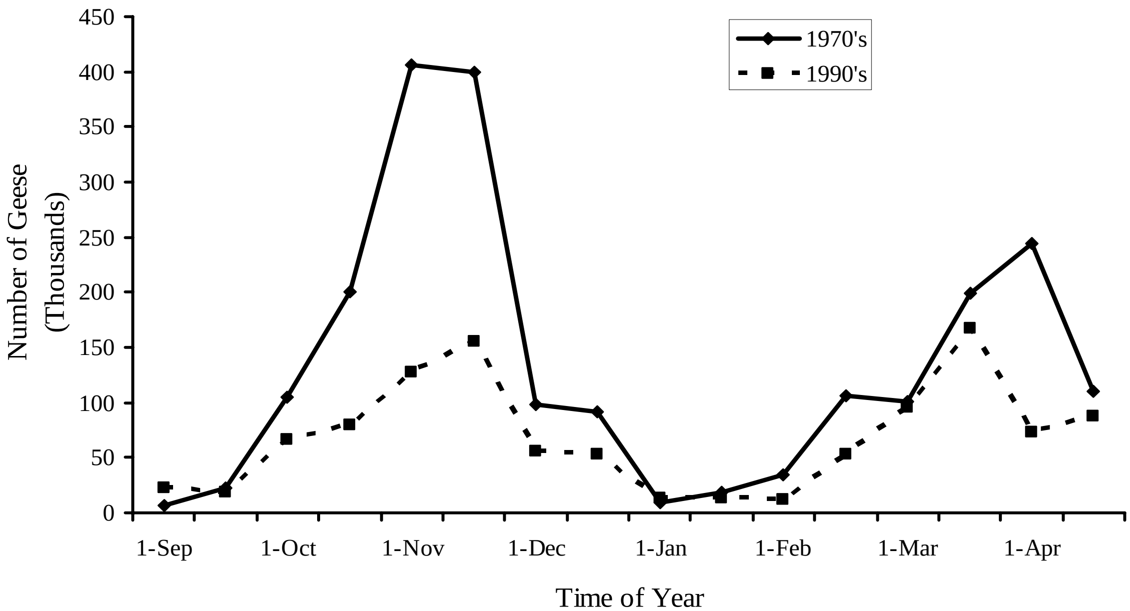


Figure 2-4. Mean counts of geese at Tule Lake and Lower Klamath National Wildlife Refuges in the 1970's (1970-1979) and 1990's (1990 -1999) determined from aerial surveys.

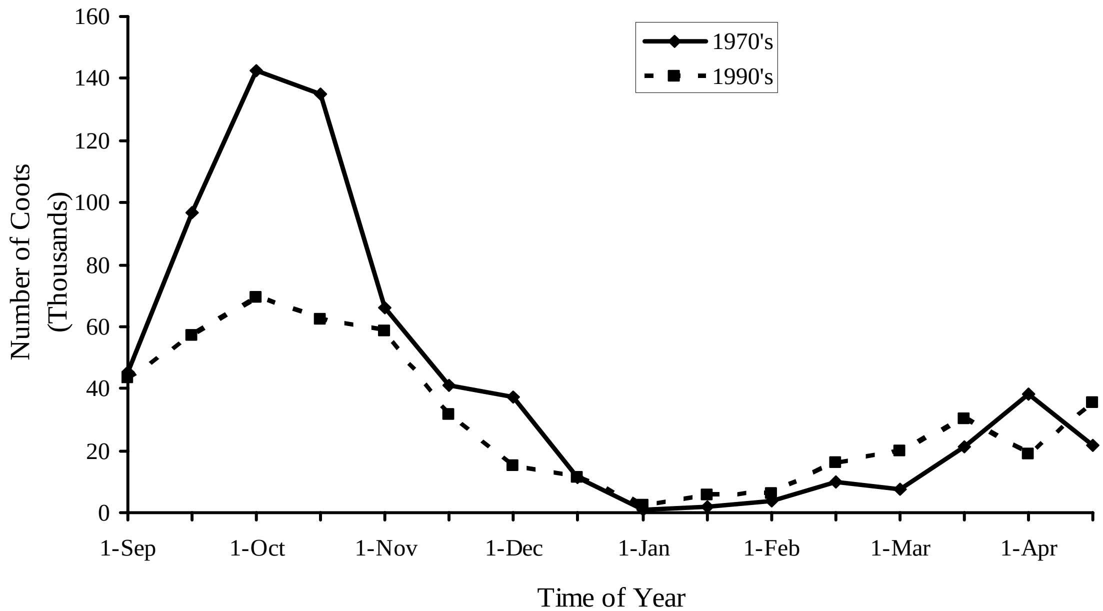
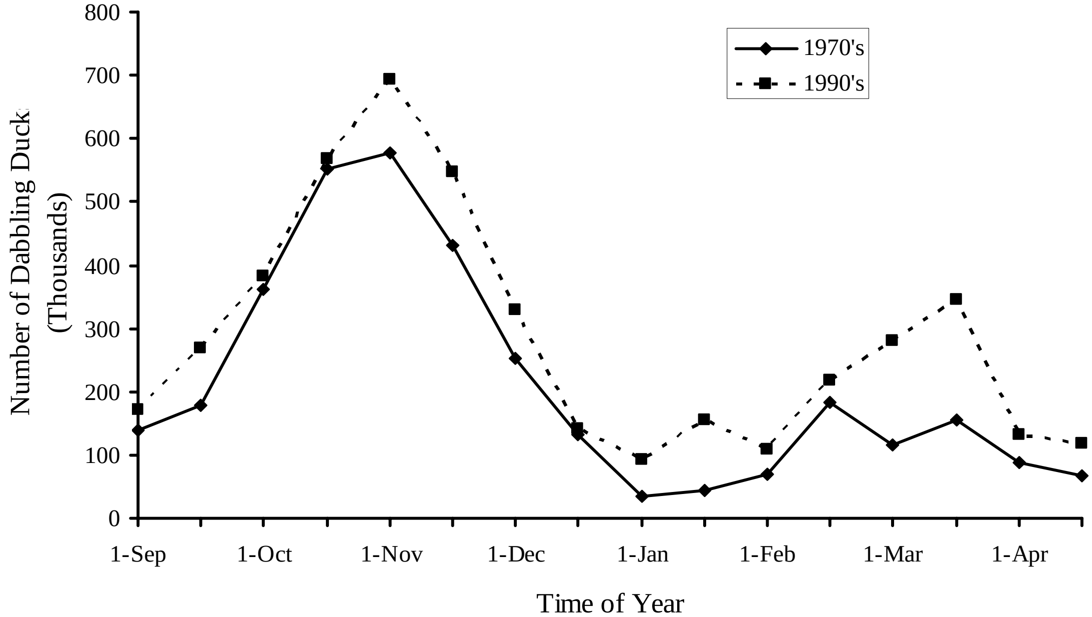


Figure 2-5. Mean counts of coots at Tule Lake and Lower Klamath National Wildlife Refuges in the 1970’s (1970-1979) and 1990’s (1990 -1999) determined from aerial surveys.

a



b

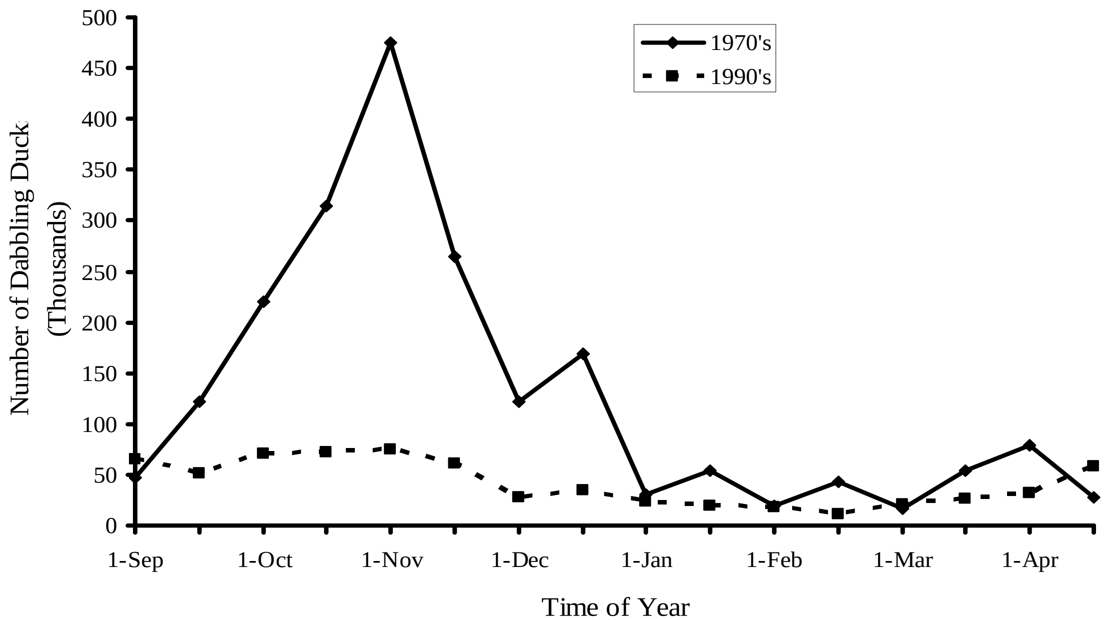
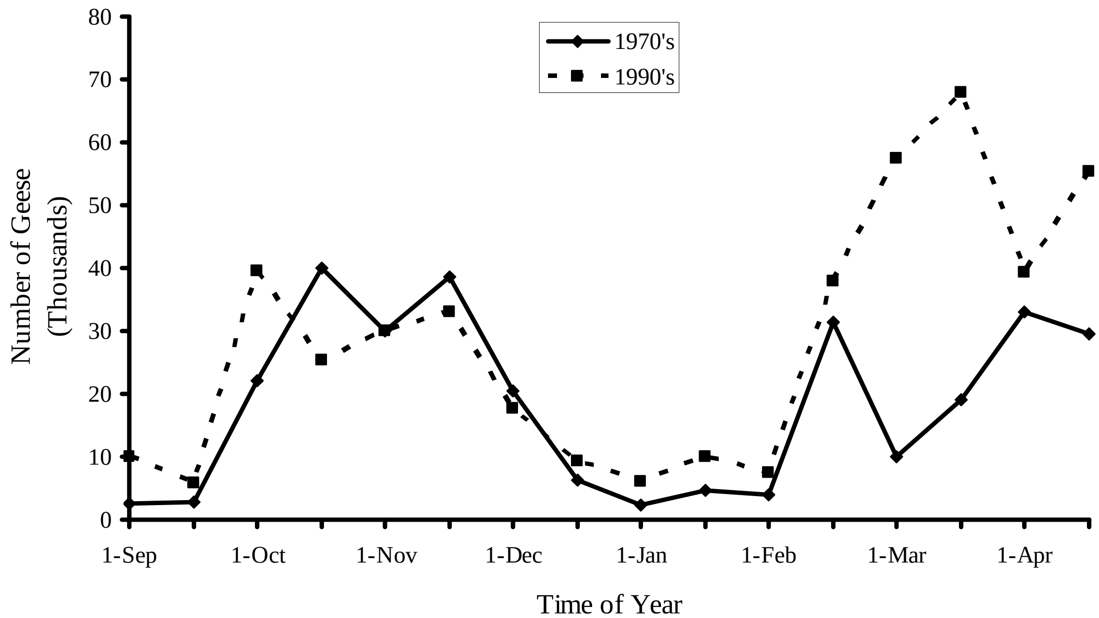


Figure 2-6. Mean counts of dabbling ducks by date at Lower Klamath NWR (a) and Tule Lake NWR (b) in the 1970’s (1970-1979) and 1990’s (1990 -1999) determined from aerial surveys.

a



b

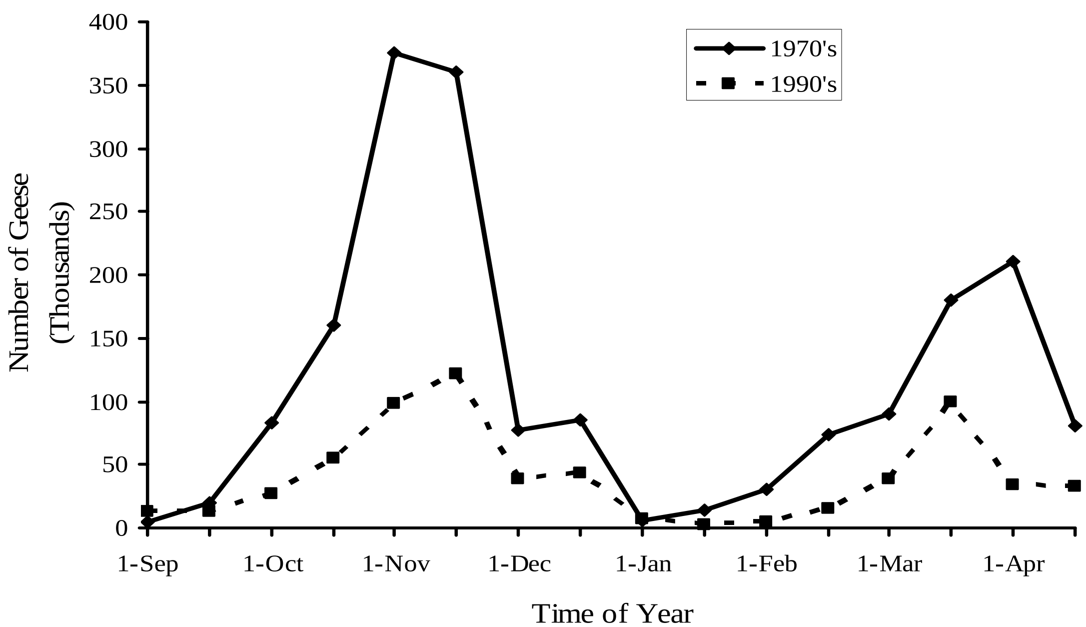
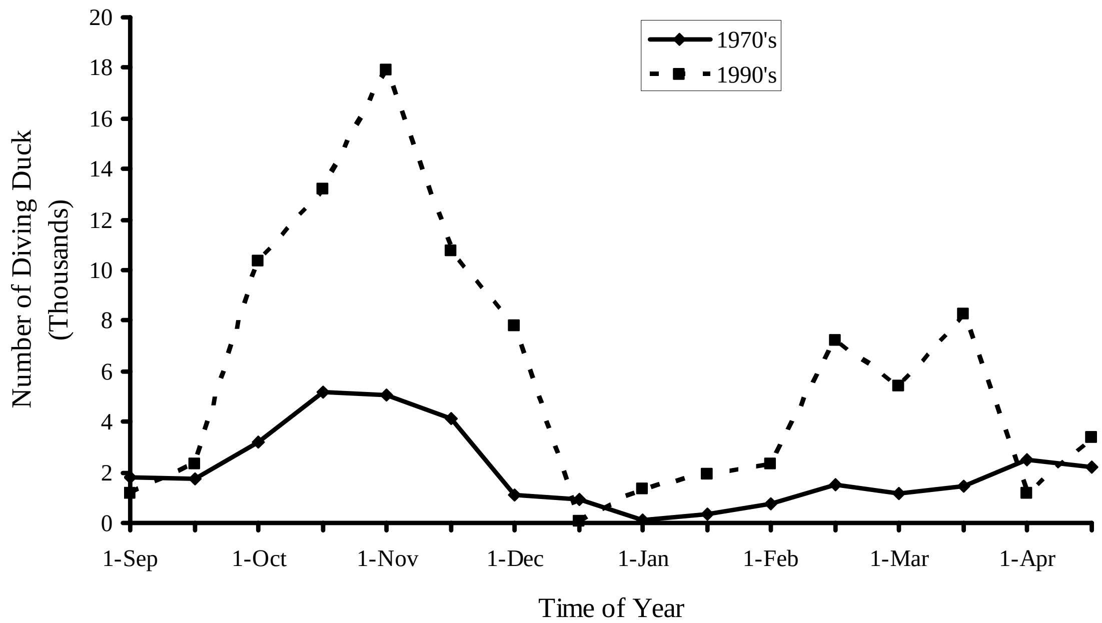


Figure 2-7. Mean counts of geese by date at Lower Klamath NWR (a) and Tule Lake NWR (b) in the 1970's (1970-1979) and 1990's (1990 -1999) determined from aerial surveys.

a



b

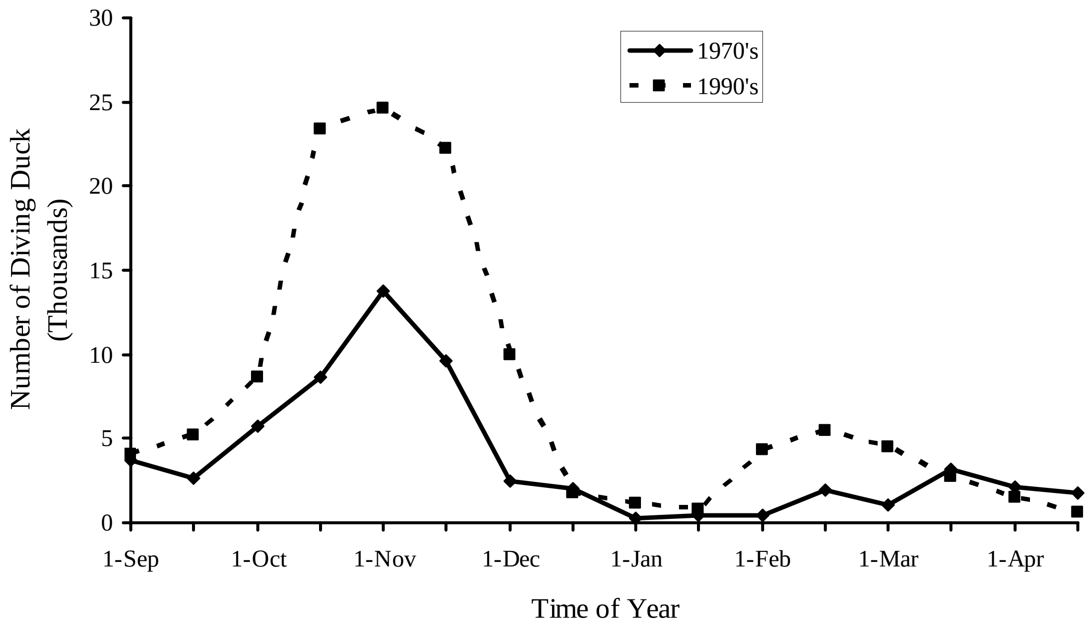
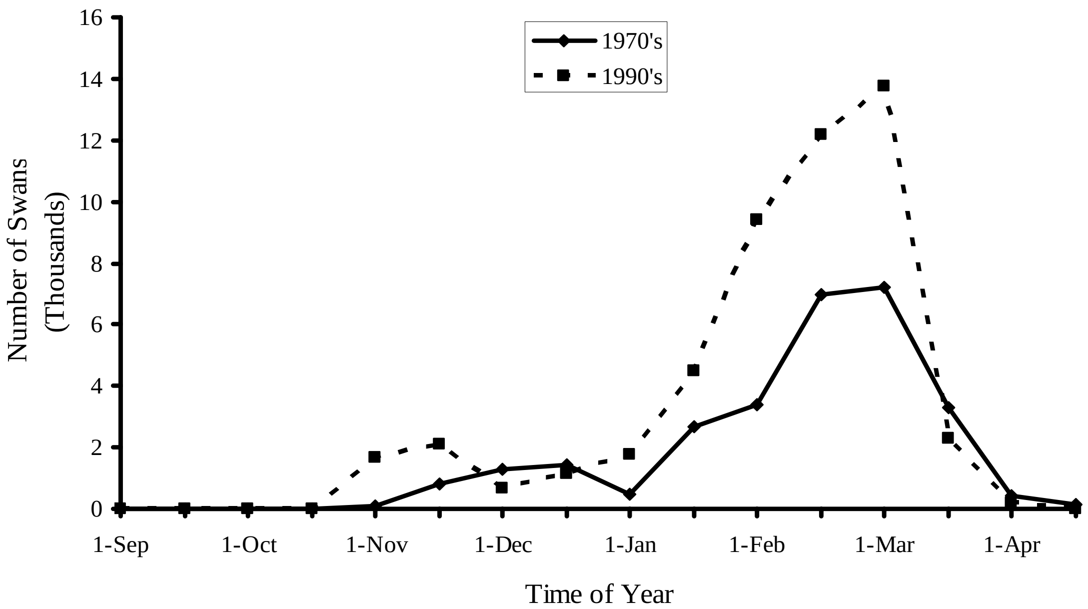


Figure 2-8. Mean counts of diving ducks by date at Lower Klamath NWR (a) and Tule Lake NWR (b) in the 1970’s (1970-1979) and 1990’s (1990 -1999) determined from aerial surveys.

a



b

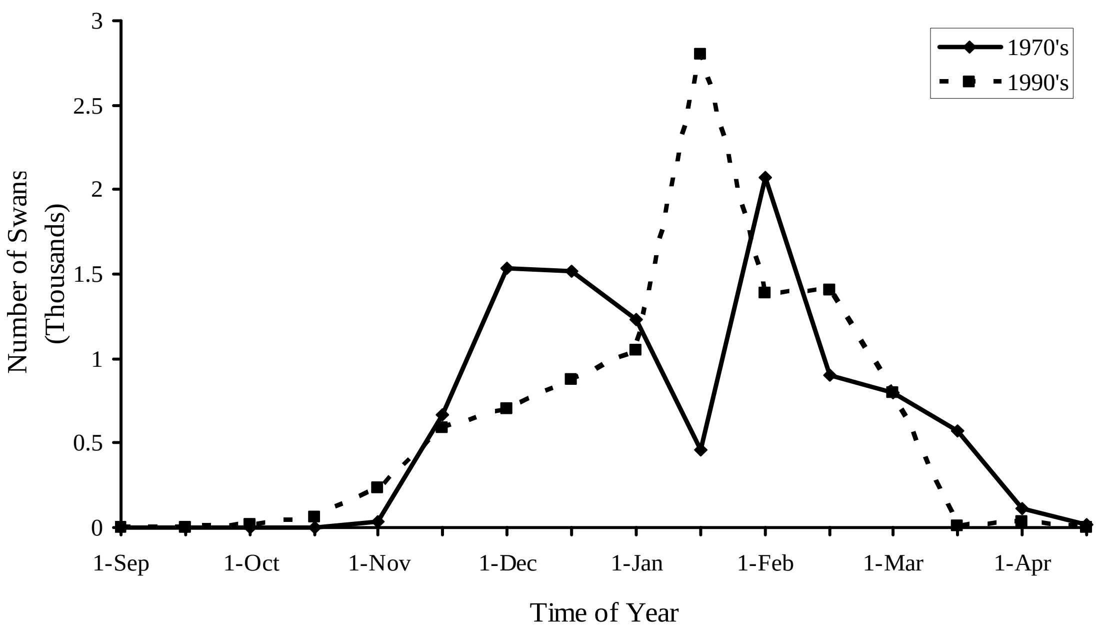
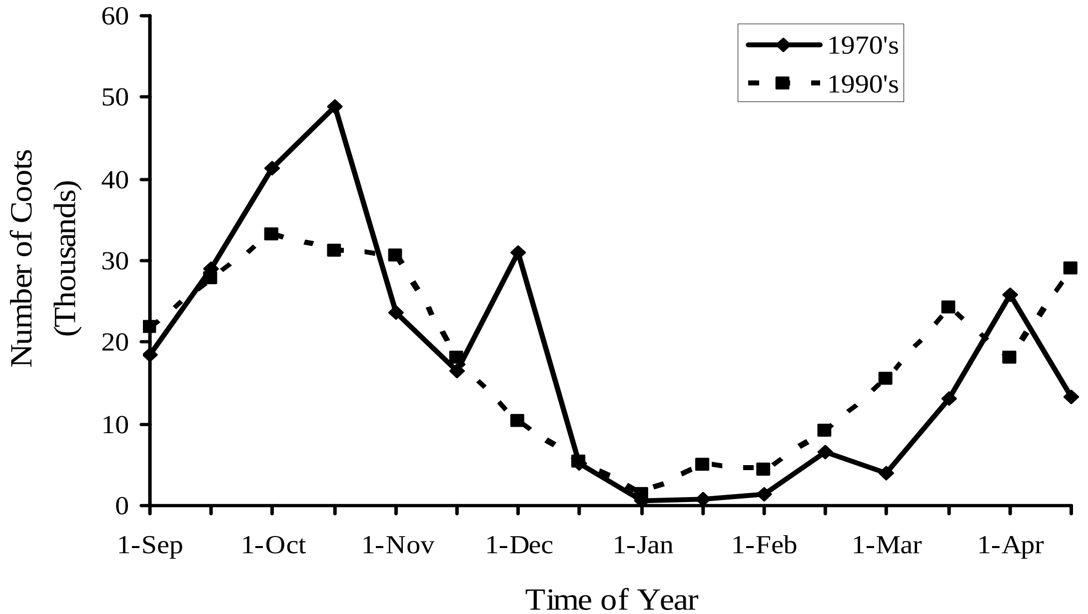


Figure 2-9. Mean counts of swans by date at Lower Klamath NWR (a) and Tule Lake NWR (b) in the 1970's (1970-1979) and 1990's (1990 -1999) determined from aerial surveys.

a



b

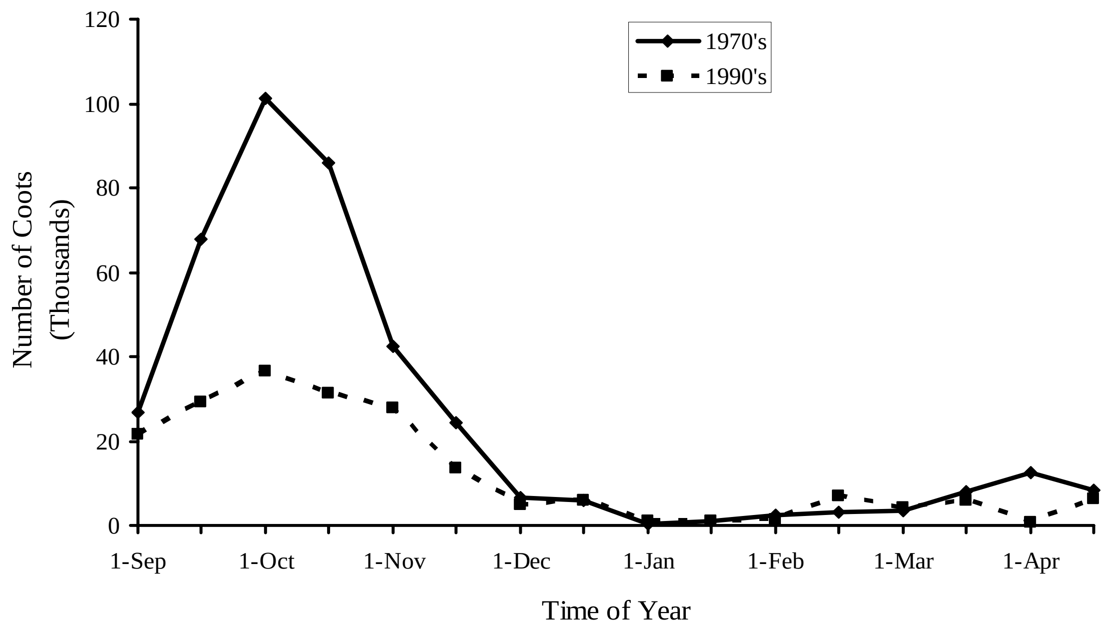


Figure 2-10. Mean counts of coots by date at Lower Klamath NWR (a) and Tule Lake NWR (b) in the 1970’s (1970-1979) and 1990’s (1990 -1999) determined from aerial surveys.

Comparison of guild composition

The species composition of the dabbling duck guild shifted between the 1970s and 1990s. During the 1970's, pintail was the most abundant dabbling duck at both refuges with estimates ranging between 55-70% at LKNWR and 40-55% at TLNWR for fall, winter, and spring (Figure 2-11 and 2-12). Mallard, wigeon, and shovelers accounted for most of the remaining birds. The relative abundance of pintails declined at both refuges in the 1990's, consistent with declines in continental pintail populations, but declines were more severe at TLNWR where pintail declined to third, fourth, and fourth most abundant dabbling duck during fall, winter, and spring (< 15% of the dabbling duck guild in each season). Mallard were the most abundant dabbler during fall and winter and shoveler most abundant during spring at TLNWR. At LKNWR, pintail were still the most abundant dabbler during fall and spring in the 1990s, while mallards were dominant in winter. Green-winged Teal increased in relative importance during the 1990s at both refuges during all seasons.

Ruddy ducks were the most abundant diving duck at both refuges during all seasons in the 1970s (Figures 2-13 and 2-14). This was followed by some combination of Canvasback, Redheads, Bufflehead and Scaup. Ruddy duck remained relatively most abundant during fall and spring during the 1990s at both refuges; however, during winter, the proportion of Canvasback and scaup were similar to Ruddy Ducks at TLNWR while Bufflehead numbers were similar to Ruddy Ducks at LKNWR. Additional information on waterfowl species composition over time for TLNWR and LKNWR can be found in Gilmer et al. (2004).

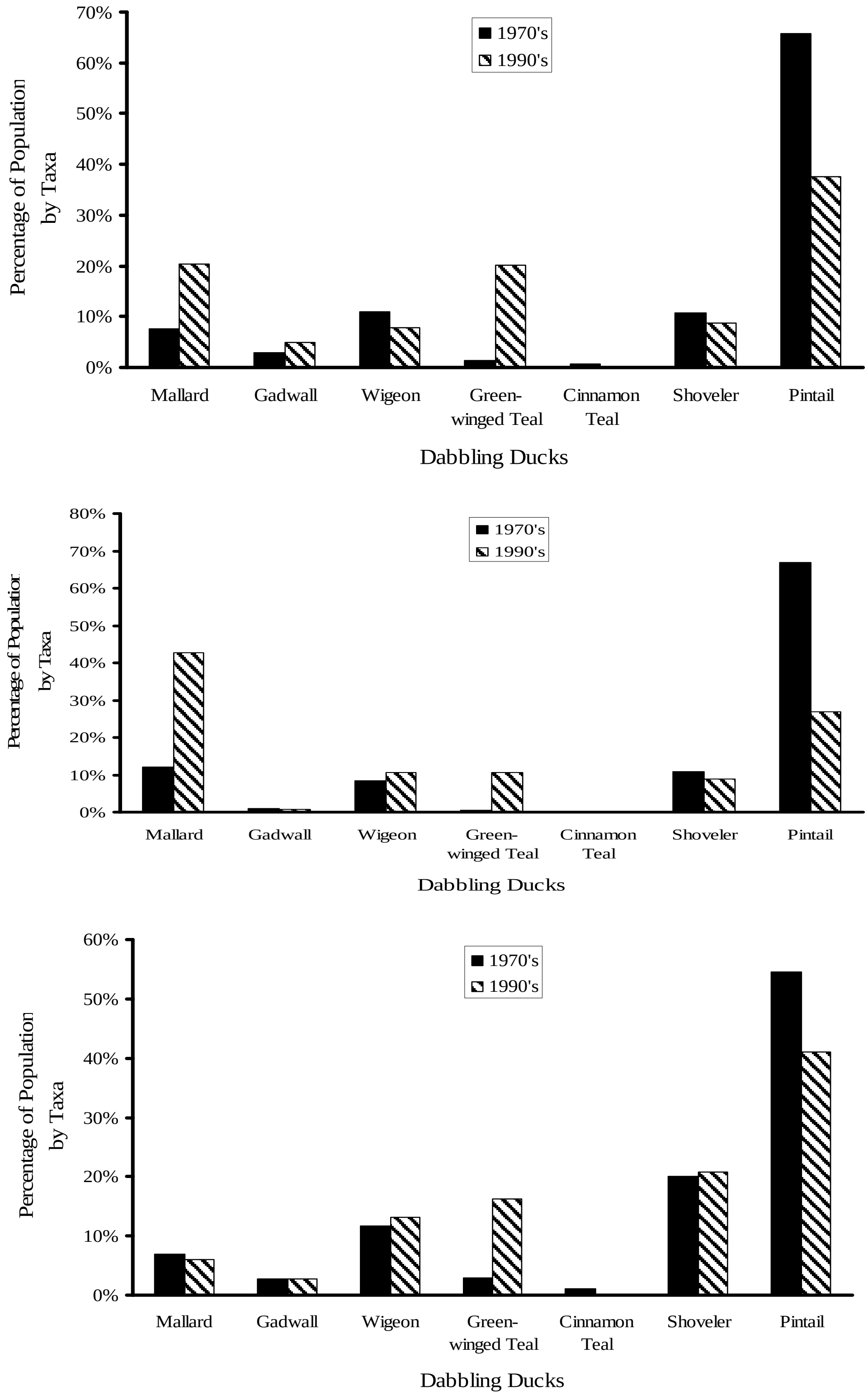


Figure 2-11. Composition of dabbling ducks guild during fall, winter, and spring (top to bottom) at LKNWR during the 1970s (1970-1979) versus 1990s (1990-1999).

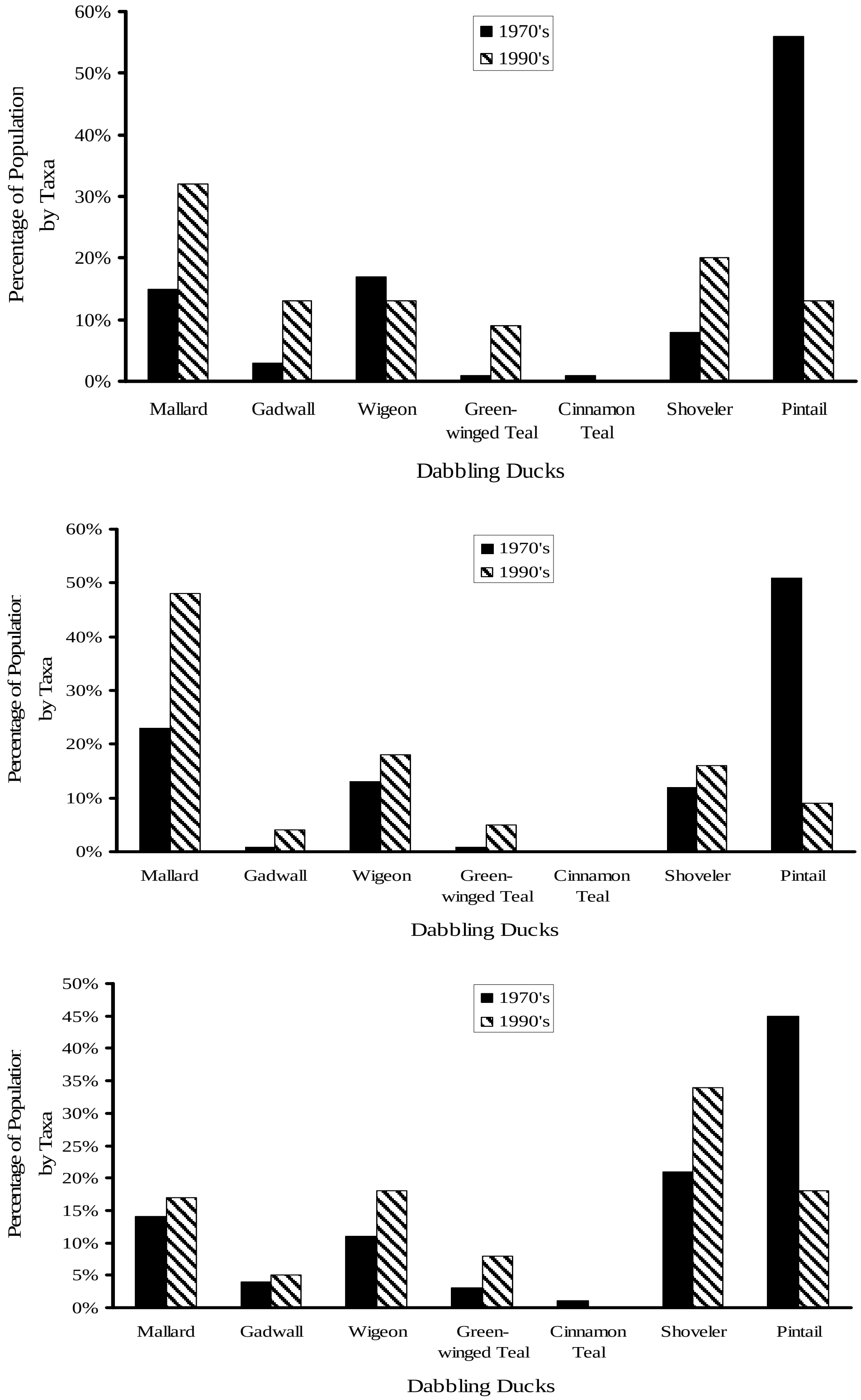


Figure 2-12. Composition of dabbling duck guild during fall, winter, and spring (top to bottom) at TLNWR during the 1970s (1970-1979) versus 1990s (1990-1999).

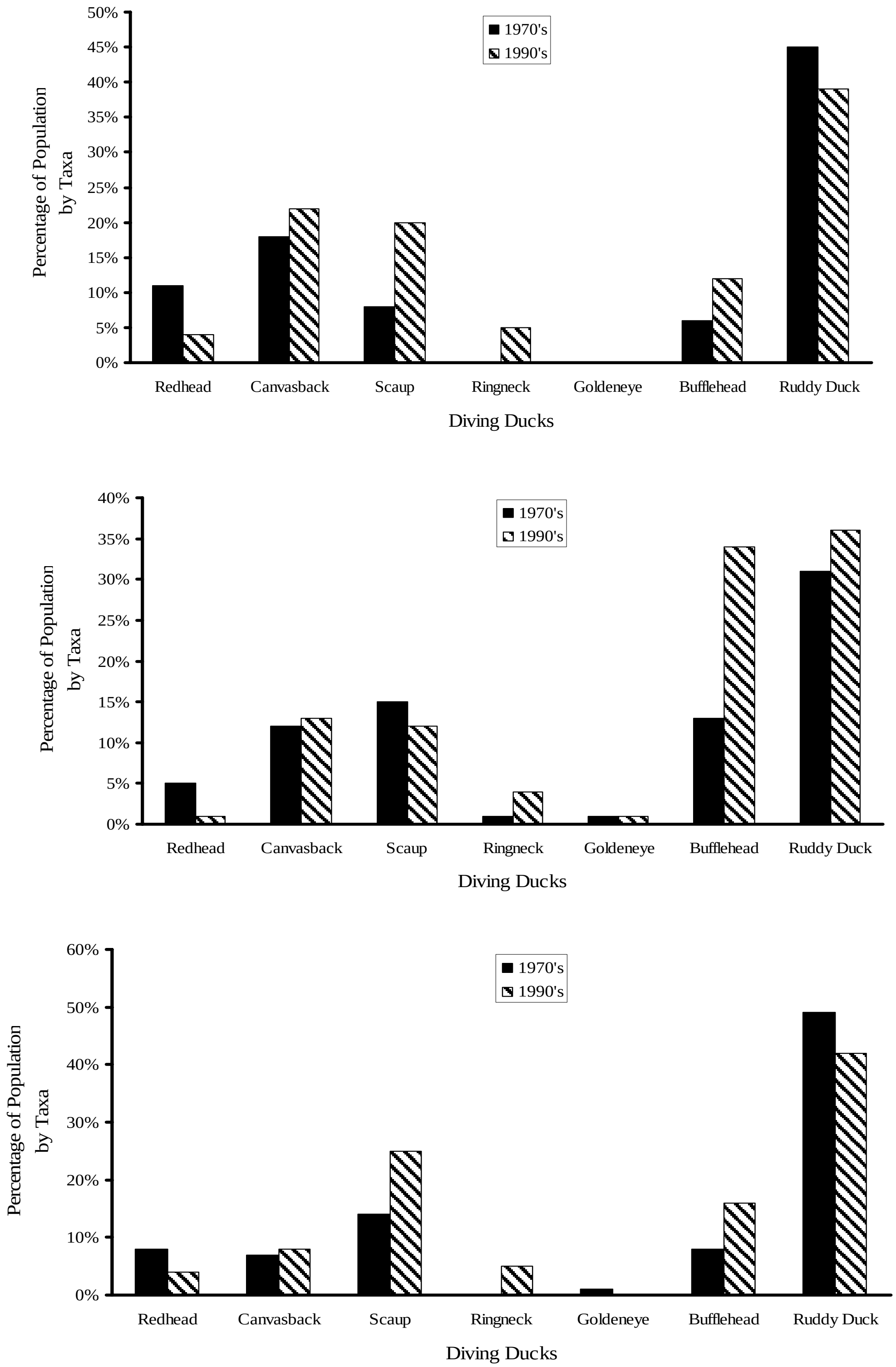


Figure 2-13. Composition of diving ducks guild during fall, winter, and spring (top to bottom) at LKNWR during the 1970s (1970-1979) versus 1990s (1990-1999).

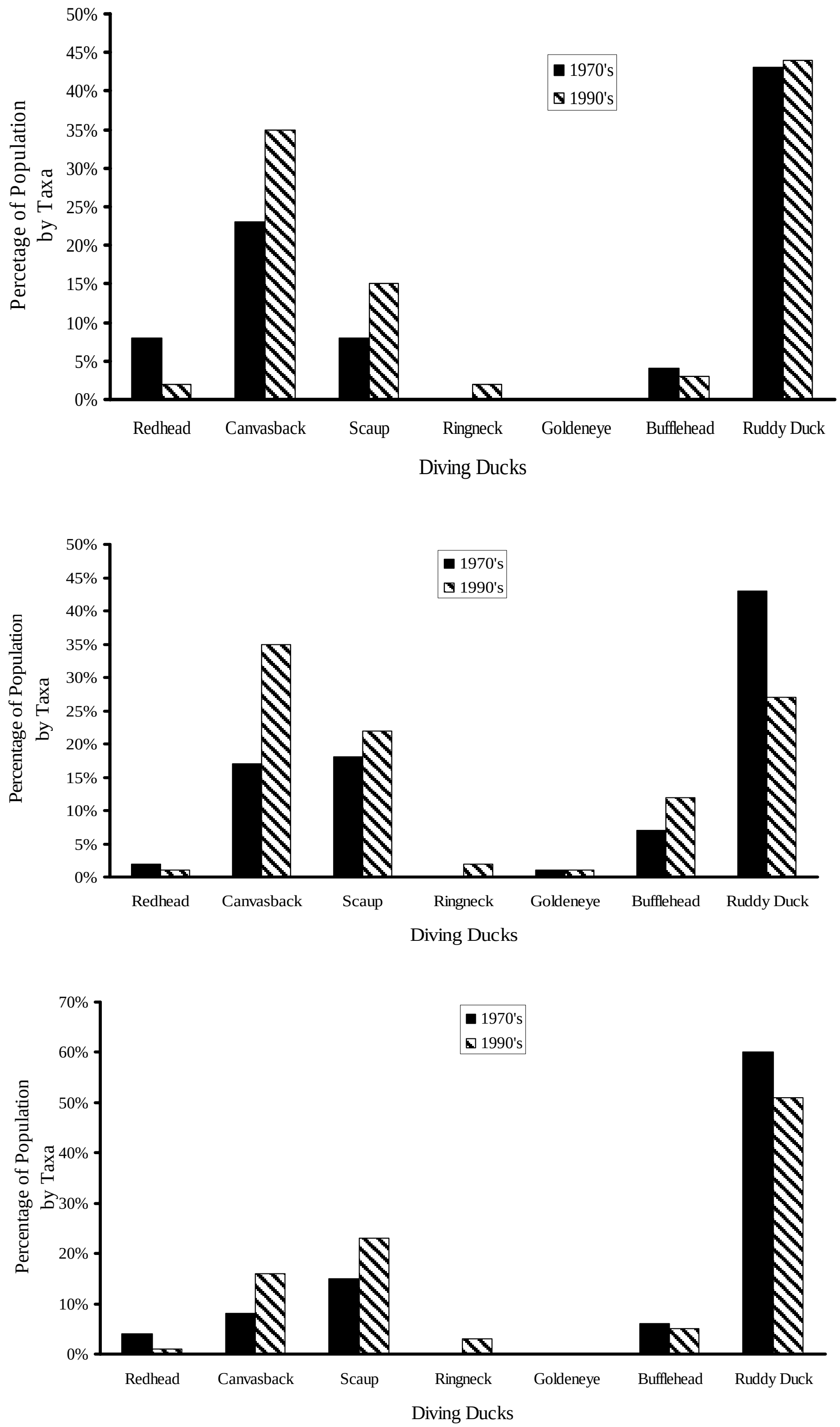


Figure 2-14. Composition of diving ducks guild during fall, winter, and spring (top to bottom) at TLNWR during the 1970s (1970-1979) versus 1990s (1990-1999).

Waterfowl population objectives

The 75th percentile for the 10 years of survey data for each survey period are shown in Tables 2-1 and 2-2. These numbers along with estimates of mean population size (Figures 2-6 through 2-10) were used as waterfowl population objectives for bioenergetic modeling scenarios outlined in chapter 4. For more detailed summary of the count data, see Appendix C.

Table 2-1. Waterfowl population objectives by date for Tule Lake National Wildlife Refuge. Objectives are 75% percentile counts from aerial surveys conducted during a 10 year period.

Date	Waterfowl Taxa or Guild[a]				
	Dabblers[b]	Divers[c]	Geese[d]	Swans	American Coot
Sept 1	53,100	4,270	14,680	0	31,000
Sept 15	54,725	2,990	10,630	0	82,575
Oct 1	292,200	6,998	37,460	0	124,900
Oct 15	281,100	10,730	82,170	0	115,200
Nov 1	765,901	16,440	136,413	260	52,375
Nov 15	268,328	11,088	146,605	713	35,925
Dec 1	193,700	3,825	50,275	1,230	10,650
Dec 15	262,400	2,200	64,608	1,125	8,000
Jan 1	37,015	193	9,240	640	300
Jan 15	91,955	675	4,040	4,205	800
Feb 1	24,635	525	8,350	1,525	2,550
Feb 15	42,850	3,115	13,935	1,530	5,300
Mar 1	16,903	1,308	44,233	1,115	3,750
Mar 15	63,486	3,388	112,708	8	12,375
Apr 1	92,620	2,555	35,705	50	14,500
Apr 15	32,975	2,638	39,595	0	10,250

[a]Species combined into guilds based on foraging method and diet. Seventy-fifth percentiles calculated for either 1970-1979 (ducks) or 1990-1999 (geese and swans), see methods for explanation.

[b]Dabblers include Mallard, Gadwall, Northern Pintail, Green-winged Teal, Cinnamon Teal, and Northern Shoveler

[c]Divers include Canvasback, Redhead, Ruddy Duck, Bufflehead, Ring-necked Duck, Goldeneye, and Scaup

[d]Geese include Canada Goose, Cackling Goose, Greater White-fronted Goose, Lesser Snow Goose, Ross' Goose

Table 2-2. Waterfowl population objectives by date period for Lower Klamath National Wildlife Refuge. Objectives are 75% percentile counts from aerial surveys conducted during a 10 year period.

Date	Waterfowl Taxa or Guild[a]				
	Dabblers[b]	Divers[c]	Geese[d]	Swans	Coots
Sept 1	213,521	2,270	7,640	0	28,000
Sept 15	219,869	1,791	5,820	0	33,250
Oct 1	401,738	3,708	51,610	0	52,863
Oct 15	597,010	7,385	36,095	0	59,925
Nov 1	597,536	6,313	34,160	1,545	23,625
Nov 15	487,361	5,783	46,855	3,193	15,925
Dec 1	372,560	1,250	19,475	930	19,500
Dec 15	198,118	855	12,488	1,398	5,500
Jan 1	10,594	160	7,430	2,490	540
Jan 15	27,171	305	12,990	7,211	550
Feb 1	77,714	800	11,431	14,043	1,750
Feb 15	223,459	2,175	56,580	14,960	8,350
Mar 1	148,414	1,560	66,248	18,995	4,850
Mar 15	203,306	1,600	80,433	3,186	11,000
Apr 1	96,775	3,600	49,880	0	45,000
Apr 15	83,339	2,020	70,185	0	16,475

[a]Species combined into guilds based on foraging method and diet. Means calculated for either 1970-1979 (ducks) or 1990-1999 (geese and swans), see methods for explanation.

[b]Dabblers include Mallard, Gadwall, Northern Pintail, Green-winged Teal, Cinnamon Teal, and Northern Shoveler

[c]Divers include Canvasback, Redhead, Ruddy Duck, Bufflehead, Ring-necked Duck, Goldeneye, and Scaup

[d]Geese include Canada Goose, Cackling Goose, Greater White-fronted Goose, Lesser Snow Goose, Ross' Goose

III. FOOD ABUNDANCE AND ENERGETIC VALUE OF KEY FOODS USED BY MIGRATORY WATERFOWL AT LOWER KLAMATH AND TULE LAKE NATIONAL WILDLIFE REFUGE

Developing and using bioenergetic models requires knowledge of the types, abundance, and nutritional value (i.e., metabolizable energy) of individual foods (Central Valley Habitat Joint Venture 2006, Loesch et al. 1994, Miller and Newton 1999, Esslinger and Wilson 2001, and Ballard et al. 2004) found in habitat types included in the model. Estimates of food abundance are available for agricultural habitats at TLNWR and LKNWR (Kapantais et al. 2003), but not for managed seasonal and permanent wetlands. Estimates of wetland seed and tuber production are available for California's Central Valley (Naylor 2002), the Mississippi Alluvial Valley (Kross 2006, Reinecke and Hartke 2005), Missouri (Greer et al. 2007), and New Mexico (Taylor and Smith 2005); however, there are no estimates for wetlands in the intermountain west. While estimates from other areas may provide a reference point for considering food production in the intermountain west, the unique physical properties and distinct plant communities in the region dictate that some site-specific sampling be conducted.

Unlike food production, the metabolizable energy (ME) of a specific food is thought to be more consistent with geography. Despite the value of knowing a food's ME, we know the ME value for only five agricultural foods, four species of acorn, one tuber, and 16 moist soil plant seeds (Hoffman and Bookhout 1985, Petrie et al. 1998, Sherfy 1999, Checkett et al. 2002, Kaminski et al. 2003), and estimates for several foods common at TL and LK are not known. Until an indirect method for estimating metabolizable energy is developed and tested (e.g., Petrie et al. 1998), direct measurements of ME are best. Several methods are available for directly estimating metabolizable energy using controlled feeding experiments; however, estimates of true metabolizable energy (TME) are most accurate (Sibbald 1976, Miller and Reinecke 1984). Unlike estimates of gross energy, TME estimates energy available to birds, and TME is preferable over estimates of apparent metabolizable energy because it accounts for fecal and urinary energy of non-food origin (Sibbald 1976, Miller and Reinecke 1984). To facilitate the development of bioenergetic models for TLNWR and LKNWR, we sampled foods in wetland habitats to achieve the following objectives:

Objectives

1. Estimate moist-soil seed biomass in early v. late seasonal wetlands.
2. Estimate tuber and green foliage produced by submerged aquatic vegetation in permanent wetlands.
3. Estimate the biomass of macroinvertebrates in seasonal wetlands during spring.
4. Estimate the true metabolizable energy value for the seeds of five plants commonly eaten by ducks in the Klamath Basin.
5. Using data from objectives 1-4, estimate energy production in seasonal and permanent wetland habitats at Lower Klamath and Tule Lake NWR.

Methods

Estimating food biomass

Sampling design.-- We estimated food biomass in seasonal and permanent wetlands on both refuges. Seasonal wetlands were classified into two groups based on time since onset of seasonal management, early v. late. Early units had been managed as seasonal wetlands for 1 or 2 years, late wetlands longer than 2 years. We made this initial distinction because plant community and seed production in seasonal wetlands are known to vary with time (Fredrickson and Taylor 1982). Changes with time are generally attributed to plant succession, and qualitative observations by the biological staff at the refuge indicated differences in the plant community did occur; consequently, while we measured plant community composition in each unit prior to sampling, we *a priori* categorized seasonal wetlands early or late successional. We sampled 3 of 5 seasonal wetlands on TLNWR (Lot 5, D-blinds, Sump 1B), and 9 of 20 seasonal wetlands on LKNWR (4A, 4F, 6A, 6B, 6C, 9B, 10B, 13B, White Lake) representing 4 early and 5 late successional units. We sampled the only permanent wetland at TLNWR (Sump 1A; Sump 1B was managed as a seasonal wetland in 2002) and randomly selected 2 of 9 permanent wetlands at LKNWR to sample.

Our sampling goal was to generate relatively precise estimates (CVs < 0.20) of food biomass in each management unit for each food type; consequently, we used one of several sampling designs (simple random, stratified random, and double sampling) based on unit-specific vegetative characteristics (Thompson 1992). When it was possible to visually partition a wetland unit into zones of distinct vegetation (habitat patches), we used stratified random sampling proportional to patch size. We first delineated the boundaries of each patch using a Global Positioning System (GPS) and all-terrain vehicle (ATV) and entered the information into a Geographic Information System (GIS). We delineated borders of vegetation communities where species composition for the selected community appeared to drop below 50%. We then calculated the proportion of each vegetation type within the unit and allocated 40 sample locations proportional to vegetation type patch size. Our sampling effort (n = 40 samples per unit) was based on previous experience with sampling moist-soil vegetation (Greer et al. 2007). To choose specific sample locations within each patch, we used GIS to lay a grid (100 m on a side) on top of each habitat patch; each node represented a potential sampling location. We then randomly selected points to sample.

We used double sampling (Thompson 1992) for units when we could visually estimate relative seed or SAV production (Thompson 1992, Reinecke and Hartke 2005). For example, we used this approach for units dominated by a single plant species. Double sampling provided a means of stratifying our sample, but rather than stratify *a priori* based on vegetation community (as above), we stratified based on our estimate of seed production as determined during the first stage of sampling. First, we created a population of possible sample locations by placing a grid onto a digital map of each unit. We varied grid cell size with unit size so there was between 300 and 400 hundred sample points. During the first stage of sampling, we used a GPS unit and either an airboat or ATV to visit each point. At each point, we characterized seed or SAV production as high, medium, or low based on visual inspection (Reinecke and Hartke 2005). For seasonal wetlands (which were dry at the time of sampling) and permanent wetlands with clear water, we visually inspected a 5 m^2 patch at each sample location. When water clarity prohibited simple visual inspection in permanent wetlands, we ran a two-sided rake (width = 0.38 m) a distance of 1 m through the water column and scored production based on the relative abundance of vegetation on the rake. Sampling effort (n = 40) was allocated proportional to estimated food production (low, medium, high) and specific sample locations for the second stage of sampling were selected as described above. We assumed that below ground biomass correlated with above ground biomass.

Finally, we used simple random sampling for units that could not be stratified or double-sampled in a meaningful manner. This was primarily due to fairly homogenous vegetation and seed production or our unfamiliarity with the dominant plants (making it difficult to characterize seed production using simple visual inspection). A random set of 40 sample locations was selected using the technique described above.

Sampling and processing seeds.-- Seed sampling occurred during late-summer, before flooding in fall. We navigated to sampling locations using a handheld GPS unit and dropped a 0.25 m^2 open-ended (horse-shoe shaped) sampling frame when the GPS unit indicated we were within 1 m of the location. We recorded percent cover for each species of plant within the sampling frame (within 5%). We then centered a 0.0625 m^2 frame within the larger sampling frame and clipped all inflorescences occurring within a column defined by that frame (Laubhan and Fredrickson 1992). Inflorescences were separated by species and placed in labeled paper bags. All species producing seeds were collected except aster and biennial wormwood, which were ignored because most seed heads were not developed and they were not utilized by waterfowl in previous food habits studies (Pederson and Pederson 1983). We also collected two soil cores (5.7 cm diameter x 8.0 cm deep) from within the 0.0625 m^2 sampling frame to account for seeds that might have dropped during clipping. Cores were labeled and frozen to prevent deterioration until processing.

In the lab, we separated seeds from detritus using a modified air separator (USDA 1968) and a series of screens with mesh sizes appropriate for each species (Appendix A). Samples were blown, sifted, and picked through until we visually estimated that ≥ 90% of the chaff mass was removed from the sample. For some species the time required to achieve our 90% standard was too great. For these, we processed a single sample as above for one hour then used that sample as a reference, and processed additional samples of the same species until the proportion of chaff and other detritus resembled the reference. To correct for the detritus, we randomly selected 10% of the samples and processed them to ≥ 90% purity, weighed the detritus that was removed, calculated the mean detritus mass, and subtracted that value from any sample not processed to ≥90% purity. All samples were then weighed to the nearest 0.0001 g.

We thawed core samples to room temperature then placed them between a #10 and #45 sieve and rinsed until clear water passed through the bottom sieve (#45); the remaining material was placed in a drying oven (60^{o} C) until dry. Samples were then run through a set of sieves (size #10, #18, #35, and #45) and seeds were sorted by species from the debris remaining on each sieve and weighed to the nearest 0.0001 g.

Seeds on the #45 screen were very small and difficult to identify. Rather than separate by species, we separated seeds into two classes (small black and other). We calculated class-specific biomass of seeds trapped by the #45 screen using the following equation:

$$\text{biomass} = n_s \text{ x } m_s \qquad (1)$$

where n_s = number of seeds on the screen and m_s = mass of a single seed. We calculated n_s as:

$$n_s = s_v \text{ x } s_d \qquad (2)$$

where s_v = the sample volume (ml) and s_d = number of seeds in a 1.2 ml subsample from each sample). Using 20 randomly selected samples, we estimated m_s as:

$$m_s = [\sum_{i=1}^{20}(w_i / n_i)]/20 \qquad (3)$$

where w_i equals the mass of a 500 seed or 0.05 g subsample from the sample and n_i was the number of seeds in the subsample.

Sampling and processing submerged aquatic vegetation.-- SAV sampling occurred during fall (Sept-Oct) and late winter (Mar). At each sample location, we firmly pressed a 61 cm^2 stovepipe sampler into the sediment then used a double-sided rake and sweep-net to remove all above ground SAV. Vegetation was placed in a zip-lock bag, labeled, and refrigerated at temperatures just above freezing for processing. We next extracted a 9.6 cm diameter sediment core (inserted 30.5 cm) from within the area contained by the stovepipe sampler. At the end of each day, roots and tubers were immediately separated from sediments, rinsed, bagged and refrigerated. In the lab, SAV vegetation was separated from algae and invertebrates and all samples were dried to a constant weight at 60°C and weighed to the nearest 0.0001g.

Sampling invertebrates.-- Invertebrate sampling was timed to coincide with peak pintail migration through the basin in spring. To make use of existing site-specific vegetation data, 30 sites/unit were randomly selected for invertebrate sampling from the 40 points sampled per unit during fall seed and SAV sampling. At each location, we drove a 25 cm diameter stovepipe sampler firmly into the sediment. We then pumped all water from the sampler through a #35 sieve using a hand pump (Diaphragm pump; 45 L per minute pumping capacity). We positioned the hose flush with the substrate so the upper layers of benthos were represented in the sample. Water depth was recorded at each location. In areas where sediments were compacted, we forced the hose into the benthos 5 times to dislodge invertebrates. Samples were labeled, preserved in formalin, and transported to the lab for future processing.

In the lab we rinsed each sample through #10 and #35 sieves. All invertebrates captured on the #10 sieve were collected. We spent 30 min picking invertebrates off of the #35 sieve then subsampled anything that remained using a modified spin separator (Waters 1969). After processing, samples were placed in a drying oven at 50°C for ≥24 hours then weighed to the nearest 0.0001 g.

We randomly selected 4 samples per unit to characterize taxonomic composition of the invertebrate community. These samples we processed using the same methods discussed while sorting specimens. Taxa were weighed separately and % composition by taxa was averaged across the 4 sites.

Calculations and statistical analyses.-- We calculated biomass using equations appropriate for the sampling design used in each unit (Thompson 1992). We standardized all site-specific biomass estimates to kg/ha. We compared seed and invertebrate biomass among wetland types using single factor ANOVAs (Proc GLM, SAS Inst. 2003).

<u>True Metabolizable Energy</u>

Feeding trials were conducted at Oregon State University in Corvallis, Oregon using game-farm male mallards (*Anas platyrhynchos*) >5 month of age. When not being used in feeding trials birds were confined in an unheated pen, subject to natural temperature and photoperiod, and provided with unlimited access to a commercial game bird ration (crude protein ≥ 20%, crude fat ≥ 3.0%, crude fiber ≤ 5.0%), grit and fresh water (Petrie et al. 1997). Husbandry practices were approved by Oregon State University's Institutional Animal Care and Use Committee (#A3229-01).

We determined TME for the seeds of 3 native species (alkali bulrush [*Scheonoplectus maritimus*], lamb's quarters [*Chenopodium album*], and common spike rush [*Eleocharis palustris*]) and perennial pepperweed (*Lepidium latifolium*), an invasive exotic. We selected the native species due to their common occurrence in wetlands in the intermountain west and presence in the diet of waterfowl (Pederson and Pederson 1983). Perennial pepperweed is eaten by mallard and pintail (*Anas acuta*; Pederson and Pederson 1983) and has invaded seasonal wetlands and riparian areas in the west where it often forms dense, monotypic stands that can effectively exclude native wetland plant species (Young et al. 1995). We obtained seeds from a commercial seed provider because, except for alkali bulrush, seeds were too small to collect a sufficient biomass from natural wetlands.

Feeding trials were conducted mid-February to early June following general procedures outlined in Checkett et al. (2002). Prior to each feeding trial, we randomly selected seven birds (*n* = 12 possible treatment birds) to serve as treatment birds. To provide a measure of endogenous contributions to excreta energy (Sibbald 1976), we selected three additional birds to serve as controls (not fed). We used the same three control birds for all trials. At the beginning of each trial, each bird (*n* = 10) was placed in a metabolic chamber (dimensions: 20 x 20 x 30 cm), provided *ad libitum* water, and fasted for 48 hrs. After fasting, but prior to feeding, we weighed each bird (± 10 g) then fed each treatment bird a known quantity of food (Sibbald 1976). For bulrush and spike rush we fed an amount equal to 1% of the bird's body mass; for perennial pepperweed and lamb's quarters we fed a reduced quantity (0.5%) because most birds regurgitated when fed 1%. Mean mass fed (± SE) was 12.5 ± 0.5 g for common spike rush, 12.1 ± 0.5 g for alkali bulrush, 6.5 ± 0.7 g for lamb's quarters, and 5.8 ± 0.2 g for perennial pepperweed. Treatment birds were fed the same species of seed for each trial.

We precision fed birds by inserting a tube (1.2 x 40 cm) into the esophagus and slowly pouring seed into the tube using a funnel and pushing seed down the tube using a wooden dowel. Seeds failing to enter the bird's esophagus (e.g., seeds clinging to the tube wall) were collected, weighed, and subtracted from each bird's original dose (Sherfy et al. 2001, Kaminski et al. 2003). Although TME estimates are theoretically independent of food-intake level (Miller and Reinecke 1984), we removed any bird from a trial if it regurgitated any portion of the test food after feeding, because the small seed size made it difficult to collect all the regurgitated seed. We conducted two trials for each food. For the second trial, only birds not successfully fed in the first trial were available for selection as treatment birds. Thus, no bird contributed more than one TME estimate for any food.

We placed metal funnels under each metabolic chamber that directed fecal and urinary matter into a plastic bag (see picture in Checkett et al. 2002). Excreta were collected from control and experimental cages 48 hrs after feeding (Petrie et al. 1998, Checkett et al. 2002, Kaminski et al. 2003). We removed feathers and grit from each sample, oven-dried the remaining excreta to constant mass at 60°C, weighed the sample to the nearest 0.0001 g, and ground with a mortar and pestle. We estimated gross energy (GE_F; kcal/g) of whole seeds and excreta using a Parr adiabatic oxygen bomb calorimeter (mean of two, 1.0 g excreta samples for each trial bird or sample of whole seed). We calculated TME (kcal/g) as:

$$TME = ((GE_F \text{ x } W_F) - (EE_F - EE_C)) / W_F$$

where GE_F was the gross energy of the whole seed, W_F was the dry mass fed (g) to the treatment bird, EE_F was the energy voided as excreta by the experimental bird (kcal), and EE_C was the energy voided as excreta by control birds (kcal/g; Sibbald 1976). The average energy excreted by control birds was used as the estimate of EE_C. To account for potentially greater catabolism of body tissue by control birds and avoid overestimating energy derived from non-food origin, we corrected TME to zero nitrogen balance (TME_N; Parsons et al. 1982, Sibbald and Morse 1982).

We determined the nutrient composition for all seeds using proximate analysis. We determined percent moisture by drying samples to a constant mass in a forced air oven at 100^{o}C and percent nitrogen using the Kjeldaul procedure (AOAC 2000). We multiplied percent nitrogen by 6.25 to estimate crude protein. We estimated crude fat using ether extraction, acid detergent fiber (ADF) and neutral detergent fiber (NDF) by the Ankom A200 filter bag technique, and ash content by heating in a cold furnace until 625^{o}C after 15 hr (AOAC 2000). We estimated crude fiber as ADF*0.80. Nitrogen Free Extract (NFE) was calculated as (100% - %water - %crude fiber - %ash - %fat - %crude protein). We expressed TME_N values as a percentage of gross energy [(TME_N /GE_F)*100%] to estimate digestive efficiency (Petrie et al. 1998).

Because bird mass may influence TME results (Sherfy 1999), we first used single factor analysis of variance (ANOVA; Proc GLM) to compare body mass among months for birds used in feeding trials and for differences in mean treatment bird mass among seed species. Mean body mass of mallards throughout the trial was 1,193.9 ± 14.1g. Body mass did not differ by date (F = 0.78, P = 0.61) or seed species ($F_{3, 22}$ = 0.43, P = 0.73), so mass was not included as a covariate in subsequent TME analyses. We determined whether TME_N of the 4 foods differed by fitting a mixed model ANOVA (Littell et al. 1996). Based on Shapiro-Wilk tests and Levene's test for homogeneity of variance, TME_N values for each seed species were normally distributed (Ws > 0.86 and < 0.96, Ps > 0.23) with equal variance ($F_{3, 22}$ = 0.45, P = 0.72). We treated seed species as a fixed effect, and included date of feeding trial and individual bird as random effects. To further examine differences in TME_N between seed species, we conducted pair-wise multiple comparisons using a Tukey multiple comparison test.

Results

Food Abundance

Plant diversity was generally higher in late vs. early successional habitats (Tables 3-1 and 3-2). Species that accounted for > 10% cover for at least one late successional unit that did not occur in early successional units included alkali bulrush, hardstem bulrush, river bulrush, perennial pepperweed, saltgrass, and spikerush. Alkali bulrush and spikerushes were the most commonly occurring dominants in late successional wetlands; whereas, early successional wetlands varied, but were dominated by pigweeds (*Amaranthus spp*.), smartweeds (*Polygonum spp.*), goosefoots and fall panicum (*Panicum dichotomiflorum*).

Seed sampling occurred from 11 September to 7 October 2002. Mean biomass estimates ranged from a low of 241 kg/ha in unit 10B to 1,425 kg/ha in unit 5 (Tables 3-3 and 3-4); the mean for early and late successional wetlands was 1,002 ± 159 kg/ha and 584 ± 91 kg/ha, respectively. The composite TME value for early and late successional wetlands was 2.38 and 1.59 kcals/g, respectively. We collected SAV samples during 2 – 7 Oct 2002 (floating vegetation and tubers) and from 4 – 13 Mar 2003 (tubers only). Mean biomass for tubers was 229.7 ± 55.7 kg/ha in fall, higher at Lower Klamath than Tule Lake (Table 3-5). Invertebrate sampling occurred 4 -13 Mar 2003; lot 5 on TLNWR was dry and not sampled. There was no difference in mean invertebrate biomass by wetland type ($F_{2,10} = 3.52$, $P = 0.07$), but the estimate in permanent wetlands was higher than for either early or established wetlands (Table 3-6). Cladocerans, Copepods, Oligochaetes, and Chironomids were the numerically dominant macroinvertebrate taxa in all wetlands (Appendix B).

Table 3-1. Mean percent cover (SE) of plants in early successional seasonal wetland units at Lower Klamath and Tule Lake National Wildlife Refuges, fall 2002.

	Wetland Unit (*n*)			
Species	5 (40)	9B (40)	DB (40)	S1B (40)
Aster	3.6 (1.2)	17.7 (3.1)	5.9 (1.9)	1.9 (1.3)
Basia	12.3 (3.0)	tr[a]	0	0
Biennial Wormwood	10.0 (2.2)	tr	tr	5.1 (2.1)
Bitter Dock	1.5 (0.6)	0	0	0
Cinquefoil	2.6 (1.0)	0	0	0
Curly dock	2.4 (1.4)	0	0	0
Dock species	4.9 (2.4)	0	0	1.6 (1.1)
Fall Panicum	0	63.9 (6.8)	0	0
Goosefoot sp.	24.3 (4.3)	1.9 (0.7)	6.1 (2.1)	18.1 (3.4)
Pigweed	12.5 (4.0)	0	25.6 (3.0)	0
Pursh Seepweed	2.1 (1.3)	9.4 (4.0)	0	0
Quackgrass	0	0	0	0
Smartweed sp.	5.1 (1.3)	0	0	40.8 (5.0)
Stinging nettle	5.8 (2.6)	0	0	0
Whitetop	0	0	0	0
Willowleaf	0	0	tr	0
Unknown	5.0 (2.1)	0	tr	tr

[a] tr < 1.0%

Table 3-2. Mean percent cover (SE) of plants in plots from late successional seasonal wetland units at Tule Lake and Lower Klamath National Wildlife Refuges, fall 2002.

	Unit (*n*)							
Species	10B (39)	13B (40)	4A (40)	4F (40)	6A (40)	6B (40)	6C (39)	WL (40)
Alkali Bulrush	2.2 (1.9)	12.6 (4.3)	6.4 (2.9)	13.3 (4.2)	10.9 (4.1)	3.4 (2.4)	37.2 (6.3)	25.8 (5.9)
Aster	tr [a]	0	1.3 (0.8)	48.5 (6.4)	1.6 (1.3)	0	7.2 (2.9)	2.1 (2.1)
Atriplex sp.	0	2.9 (2.4)	0	0	tr	2.5 (1.9)	0	0
Baltic Rush	0	0	0	0	0	2.6 (2.2)	0	0
Basia	0	0	0	tr	1.9 (1.9)	1.3 (1.3)	0	2.1 (2.0)
Biennial Wormwood	tr	0	tr	tr	1.4 (0.8)	1.1 (0.6)	1.1 (1.0)	0
Canadian Thistle	0	0	0	0	0	1.6 (1.2)	0	0
Chenopodium sp.	1.5 (1.3)	20.0 (5.2)	1.5 (0.9)	24.3 (5.8)	2.9 (1.5)	tr	3.2 (1.4)	6.8 (1.9)
Foxtail Barley	tr	0	4.4 (2.6)	0	2.6 (1.6)	0	0	0
Hardstem Bulrush	0	9.0 (3.6)	4.6 (2.8)	0	12.0 (5.1)	1.4 (1.3)	1.8 (1.8)	0
Nutalls' Alkali-grass	11.2 (4.3)	0	0	0	0	0	0	2.1 (2.1)
Panicum	0	0	0	1.9 (1.9)	0	0	0	0
Perrenial Pepperweed	0	0	10.2 (4.7)	2.3 (2.3)	0	7.5 (4.2)	0	0
Pursh Seepweed	0	0	0	0	0	0	0	11.3 (3.7)
Quackgrass	0	0	2.6 (1.9)	0	0	tr	0	0
Rabbitfoot Grass	3.2 (1.8)	0	0	0	2.9 (2.5)	1.4 (1.1)	tr	0
River Bulrush	0	48.8 (7.5)	0	0	0	0	4.6 (3.2)	0
Rorripa	tr	0	0	0	0	1.8 (0.7)	0	0
Rumex sp.	tr	2.4 (1.6)	9.5 (3.2)	0	tr	tr	tr	0
Rushes (juncus)	4.9 (2.8)	0	0	0	0	0	0	0
Saltgrass	8.2 (4.0)	0	3.6 (2.5)	0	tr	10.1 (4.4)	1.3 (1.1)	9.8 (4.6)

Table 3-2 cont…

	Unit (*n*)							
Species	10B (39)	13B (40)	4A (40)	4F (40)	6A (40)	6B (40)	6C (39)	WL (40)
Scratchgrass Muhly	0	0	0	0	0	2.3 (2.3)	0	tr
Smartweeds	tr	0	0	2.0 (1.6)	2.1 (1.0)	0	0	0
Spikerushs	49.8 (7.5)	0	29.2 (6.7)	0	20.5 (5.7)	15.1 (4.8)	21.9 (5.7)	0
Swamp Timothy	0	0	0	0	0	2.4 (1.9)	5.0 (2.2)	1.3 (1.0)
Whitetop	tr	0	0	0	0	4.9 (1.9)	0	0
Wormseed	1.3 (0.8)	0	13.1 (4.5)	0	6.1 (2.5)	tr	0	0
Unknown	2.6 (1.6)	0	8.9 (4.1)	2.5 (2.5)	2.4 (1.9)	8.8 (3.4)	0	0
Unknown forb	0	tr	tr	0	tr	1.3 (0.9)	tr	0

[a] tr < 1.0%

Table 3-3. Mean seed biomass (kg/ha) estimated from clip and soil core samples for plant species occurring in early successional seasonal wetland units at Tule Lake and Lower Klamath National Wildlife Refuges, fall 2002.

	Unit (*n*)			
Species [a]	5	9B	DB	S1B
Alkali bulrush	0	2.1 (2.1)	0	tr [b]
Bulrush sp.	15.1 (3.2)	37.1 (8.5)	3.6 (1.4)	265.7 (125.6)
Dock	193.5 (67.0)	tr	tr	62.9 (27.5)
Smartweeds	91.1 (27.5)	1.5 (0.9)	tr	379.8 (101.4)
Fall Panicum	0	759.6 (116.5)	0	0
Swamp Timothy	0	3.5 (3.5)	0	0
Goosefoot sp.	553.5 (102.9)	48.1 (11.2)	59.4 (25.2)	87.5 (23.0)
Pigweeds	380.4 (143.7)	0	584.6 (80.1)	0
Pursh seepweed	14.4 (13.3)	49.9 (22.6)	0	0
othr45	1.8 (0.7)	tr	tr	6.0 (2.7)
Atriplex	1.5 (1.5)	0	tr	0
Basia	72.7 (26.4)	9.1 (7.5)	0	0
Cinquefoil	7.4 (3.4)	0	0	0
Kochia	67.7 (44.1)	0	0	0
Perennial Pepperweed	0	0	0	2.9 (2.9)
Salt heliotrope	tr	0	0	40.8 (18.2)
Wormseed	1.7 (0.8)	0	0	0
#45 screen, goosefoot	18.3 (3.6)	7.5 (0.8)	2.3 (0.4)	148.3 (33.7)
Unknown forb	3.1 (2.2)	0	0	0
Unknown	3.2 (2.5)	40.5 (23.1)	tr	tr

[a] Species whose biomass never exceeded 1 kg/ha in any unit are not shown
[b] tr < 1.0 kg/ha

Table 3-4. Mean seed biomass (SE) estimated from clip and soil core samples by plant species in late successional seasonal wetland units (n) at Lower Klamath and Tule Lake National Wildlife Refuges, fall 2002.

	Wetland Unit							
Species [a]	10B	13B	4A	4F	6A	6B	6C	WL
Alkali Bulrush	0	68.3 (39.1)	40.1 (25.1)	50.4 (29.5)	22.3 (15.2)	1.3 (0.9)	183.3 (55.5)	227.6 (74.2)
Atriplex sp.	tr [b]	3.2 (3.0)		0	17.6 (13.8)	19.4 (17.4)	2.8 (1.8)	
Baltic Rush	0	0	7.9 (7.9)	0	0	0	1.8 (1.8)	
Basia	0	0		tr	20.0 (20.0)	tr	tr	13.0 (11.9)
Bulrush sp.	6.3 (2.9)	424.2 (54.1)	122.0 (27.4)	240.4 (48.1)	186.7 (38.0)	28.7 (11.0)	238.3 (39.9)	62.9 (19.0)
Dock	53.1 (26.9)	22.7 (8.5)	442.8 (129.1)	19.8 (8.4)	396.5 (102.0)	138.5 (65.8)	38.0 (19.8)	tr
Field Pennycress	tr	tr	2.6 (2.4)	0	4.7 (2.5)	1.3 (1.0)		
Foxtail Barley	3.7 (1.9)	0	6.9 (3.6)	0	33.0 (19.1)	tr		3.4 (3.2)
Goosefoot	8.2 (2.2)	132.7 (32.9)	17.8 (5.3)	124.6 (28.4)	31.5 (8.6)	25.6 (5.7)	46.3 (8.5)	49.6 (11.0)
Hardstem Bulrush	0	16.2 (11.3)	tr	0	3.1 (2.9)	tr	1.1 (1.1)	
Mustard sp.	tr	0	84.5 (42.7)	0	7.4 (6.1)	0		
Nutalls' Alkali-grass	tr	0		0	0	0		tr
Fall panicum	1.3 (0.6)	0		3.6 (1.9)	tr	tr	tr	1.9 (1.9)
Perennial Pepperweed	0	tr	3.7 (2.4)	9.3 (9.3)	0	14.9 (10.5)		
Pigweed	tr	tr	tr	0	1.3 (1.3)	tr	1.1 (1.1)	
Poison Hemlock	0	0		0	0	0	5.8 (5.8)	
Pursh Seepweed	tr	0		tr	0	0		36.4 (12.2)
Rabbitfoot Grass	7.2 (4.2)	0		tr	21.7 (19.4)	2.7 (2.1)	tr	tr
River bulrush	6.6 (6.6)	102.2 (34.4)		0	0	0		
Salt Heliotrope	tr	tr		tr	0	0		1.5 (1.5)

Table 3-4 cont…

	Unit							
Species	10B	13B	4A	4F	6A	6B	6C	WL
Saltgrass	0	1.3 (1.3)	12.9 (12.9)	0	0	tr	tr	tr
Smartweed sp.	1.6 (1.6)	3.7 (1.9)	tr	tr	20.8 (12.7)	tr	tr	tr
Spikerush	118.4 (44.7)	tr	108.7 (39.6)	tr	57.0 (11.6)	51.1 (22.2)	87.6 (28.5)	
Swamp Timothy	tr	0		8.6 (8.6)	0	2.1 (1.5)	10.1 (5.3)	6.8 (4.5)
Whitetop	tr	0		0	0	11.5 (10.2)	tr	
Wormseed	0	0		0	15.0 (13.5)	0		
#45 goosefoot	11.8 (2.2)	40.6 (7.2)	9.9 (2.7)	25.4 (3.4)	24.8 (4.5)	15.1 (4.5)	30.5 (5.0)	19.4 (3.3)
# 45 other	tr	2.9 (1.0)	8.5 (3.4)	1.8 (0.6)	11.1 (2.8)	1.3 (0.7)	3.7 (0.9)	tr
Unknown	22.6 (0.73)	tr	4.9 (3.4)	tr	15.2 (9.1)	9.8 (4.8)	tr	5.3 (4.9)

[a] Species whose biomass never exceeded 1 kg/ha in any unit are not shown

[b] tr < 1.0 kg/ha

Table 3-5. Mean biomass [kg/ha (SE)] of submerged aquatic vegetation (SAV) in permanent wetlands sampled during October and March during 2003 at Lower Klamath and Tule Lake National Wildlife Refuges.

		SAV				
		leafy vegetation		rhizomes and tubers		
Refuge	Unit	Oct 2002	Mar 2003	Oct 2002	Mar 2003	Depletion (%)
TLNWR	S1A	188 (26)	0	106 (23)	118 (33)	-0.1
LKNWR	3A	371 (56)	0	249 (60)	98 (29)	60.6
	12C	226 (53)	0	334 (53)	112 (26)	66.5
Mean		*261.7 (55.7)*		*229.7 (66.5)*	*109.3 (5.9)*	

Table 3-6. Mean biomass [kg/ha (SE)] of invertebrates in seasonal and permanent wetlands sampled during 4-13 March 2003 at Lower Klamath (LK) and Tule Lake (TL) National Wildlife Refuges.

Wetland type	Refuge	Unit	Biomass
Seasonal early	TL	D-Blinds	7.9 (1.8)
	TL	Sump 1B	12.1 (1.8)
	LK	9B	1.7 (0.6)
Mean of means			*6.0 (2.5)*
Seasonal established	LK	4A	1.3 (1.0)
	LK	4F	5.1 (0.6)
	LK	6A	16.4 (4.0)
	LK	6C	15.3 (2.2)
	LK	10B	1.9 (0.6)
	LK	White Lake	5.4 (1.2)
Mean of means			*7.6 (2.7)*
Permanent			
	TL	Sump 1A	10.2 (3.5)
	LK	3A	17.1 (2.8)
	LK	12C	45.6 (5.6)
Mean of means			*24.3 (10.8)*

TME values

TME_N differed among seed species ($F_{3, 20}$ = 80.5, P < 0.0001; Table 3.7). Pair-wise comparisons indicated mean TME_N differed for all pairs of seeds ($Ps \leq 0.002$) except alkali bulrush and common spike rush (P = 0.49). TME was highest for lamb's quarters, which was 2.2 times higher than perennial pepperweed, 3.9 times higher than alkali bulrush, and 5.0 times higher than spike rush. Digestive efficiency ranged from lows of 12.0% and 13.0% for common spike rush and alkali bulrush, respectively, to 25.9% for perennial pepperweed, and 57.6% for lamb's quarters. Perennial pepperweed seeds were high protein and fat content, but intermediate metabolizable energy value (Table 3-7). Common spike rush was highest in fiber and ash, while alkali bulrush was highest in carbohydrates (NFE).

Table 3-7. Gross energy (GE), least-squares predicted means (± SE) of nitrogen-corrected true metabolizable energy (TME_N), and nutrient composition (% dry mass basis) for the seeds of moist-soil plant species fed to adult, game-farm male mallards February - June 2003.

		GE_F	TME_N	Nutritional composition (%)[b]					
Plant species[a]	*n*	kcal/g	kcal/g	Protein	Fat	Ash	NFE[c]	ADF	NDF
alkali bulrush	7	4.42	0.65 ± 0.080	7.6	4.0	2.7	66.3	24.3	39.2
lamb's quarters	7	4.46	2.52 ± 0.080	16.6	9.5	4.1	48.4	26.7	27.0
pepperweed	5[c]	5.32	1.31 ± 0.090	26.6	20.3	4.9	36.4	14.9	38.6
spike rush	7	3.93	0.50 ± 0.080	7.5	5.5	12.5	46.5	34.8	47.9

[a] alkali bulrush (*Scheonoplectus maritimus*); lamb's quarters (*Chenopodium album*); perennial pepperweed (*Lepidium latifolium*); common spike rush (*Eleocharis palustris*)

[b] ADF = acid detergent fiber, NDF = neutral detergent fiber, NFE = 100% - (protein + fat + fiber + ash)

[c] reduced sample size caused by regurgitation of food by fed birds

IV. Evaluating Current Habitat Conditions and Exploring Management Alternatives for Meeting Waterfowl Food Energy Needs at Tule Lake and Lower Klamath National Wildlife Refuges.

Introduction

Increasing competition in the Klamath Basin for limited water supplies requires that the Service articulate its habitat objectives for waterfowl. Ideally, these objectives are based on explicit population-habitat models that reflect the life history needs of migrating and wintering waterfowl. The establishment of waterfowl population objectives for TLNWR and LKNWR in Chapter 2 is an important step in developing management actions that are biologically defensible. However, the capacity of TLNWR and LKNWR to meet these population objectives under existing and alternative management scenarios must also be evaluated if the resources needed by waterfowl are to be fully justified. Such an approach is consistent with the Service's recent Strategic Habitat Conservation Initiative that encourages a direct link between population objectives and the implementation of conservation programs.

For migrating and wintering waterfowl, food is believed to be the most limiting resource. As a result, conservation planning for waterfowl outside of the breeding season has largely focused on providing sufficient foraging habitat. Within this chapter, we used a bioenergetic model to estimate the food energy supplies available to waterfowl at TLNWR and LKNWR.

Objectives

In this chapter, we address three of the five objectives listed in Chapter 1 including:

3. Evaluate current refuge management practices relative to waterfowl food energy needs for each refuge.
4. Identify foraging habitat deficiencies that may exist for each refuge.
5. Evaluate potential habitat management alternatives for meeting waterfowl food energy needs.

Our intent with objective 5 is not to examine all the management alternatives that the Service may wish to consider. Rather, it is to provide examples of how a bioenergetic model can be used to inform habitat planning for migrating and wintering waterfowl. In the future, the Service plans to develop and refine a more complete set of management alternatives for evaluation through its Comprehensive Conservation Planning and National Environmental Policy Act (NEPA) process.

Methods

We incorporated data on energy supply and demand into TRUEMET, a bioenergetic model developed for initial use in conservation planning by the California Central Valley Habitat Joint Venture. The model provides an estimate of population energy demand and population energy supply for specified time periods. Population energy demand is a function of period specific population objectives and the daily energy requirement of individual birds during that period. Population energy supply is a function of the foraging habitats available and the biomass and nutritional quality of foods contained in these habitats. A comparison of energy supply vs. energy needs provides a measure of how well refuge habitats meet the energy needs of their target waterfowl populations. Conceptually, TRUMET is a daily ration model (Goss-Custard et al. 2003) with a model structure that assumed birds were ideal free foragers that did not incur costs associated with traveling between foraging patches (e.g., moving between wetland management units). There are seven explicit inputs required for each model run:

1. number of days or time periods being modeled
2. population size for each waterfowl guild being modeled during each time period
3. daily energy requirement of a single bird within a foraging guild
4. acreage of each habitat available for each time period
5. biomass of food in each habitat type on day one
6. nutritional quality of each food type, and
7. percentage of a bird's daily energy needs met on site and the habitats or food types each guild uses to satisfy its daily energy requirements.

<u>Model Inputs</u>

Number and Days Being Modeled.-- Migrating and wintering waterfowl rely on TLNWR and LKNWR in significant numbers between early September and late April

(Gilmer et al. 2004). As a result, we modeled waterfowl food energy needs and food energy supplies for all two-week intervals between 24 August and 22 April.

Daily Energy Requirements of a Single Bird.-- To estimate the daily energy need for a bird in each guild, we multiplied resting metabolic rate (RMR) by three to account for energy costs of free living (Miller and Eadie 2006). We used the following equations for estimating RMR:

RMR (kJ/day) = 433 * (body mass in kg) $^{0.785}$ (dabblers divers, and coots)

RMR (kJ/day) = 419 * (body mass in kg) $^{0.719}$ (geese)

RMR (kJ/day) = 413 * (body mass in kg) $^{0.689}$ (swans)

Because we modeled by guild (a group of species) and species vary in size, we calculated the body mass for a representative bird in each guild as the weighted mean for all species in each guild assuming equal sex ratios for all species. We used body mass values from Bellrose (1980) for ducks, geese, and swans and Alisauskas and Arnold (1994) for coots. We calculated the weighted mean for each two week survey period to account for changes in species composition as indicated by the aerial survey (Gilmer et al. 2004). We held body mass constant across time for dabblers, divers, coots, and swans, but we allowed mass to vary for Ross' Geese, Lesser Snow Geese, Greater White-fronted Geese, and Cackling geese based on data from Ely and Raveling (1989), McLandress (unpublished data), and Raveling (1979). Body mass for Western Canada geese was obtained from Bellrose (1980) and was held constant over time.

Habitat Acreage.-- We modeled six habitat types including harvested and un-harvested grain crops, harvested potato fields, alfalfa/hay, and seasonal and permanent wetlands. Seasonal wetlands are typically flooded in fall or winter with water removal occurring in spring or early summer; permanent wetlands are flooded at least 12 months. Seasonal wetlands were further divided into early and late successional habitats to reflect differences in seed production (Chapter 3) and permanent wetlands were divided into area dominated by submerged aquatic vegetation or robust emergent vegetation (primarily hardstem bulrush and cattail). Food production in permanent wetland areas dominated by robust emergents was set at 0.0 because the dense growth and tall, robust stature of these plants make foods in these habitats unavailable to waterfowl. Seeds that might have been produced by this plant community that dispersed into other habitats would have been included in food abundance estimates. Refuge personnel provided information on existing habitats at TLNWR and LKNWR (data for 2005). Waterfowl that rely on the refuges were assumed to exploit both agricultural and wetland habitats to meet food energy needs (Tables 4-1 and 4-2); we used these values to reflect current refuge habitat conditions.

Temporal Variation in Habitat Availability.-- Availability refers to the ability of waterfowl to access foods produced in a habitat. Availability varies with flooding conditions and crop harvest practices and can vary among guilds for a specific habitat type. For example, many species of ducks will not feed in dry agricultural fields or wetlands (e.g., diving ducks), but Mallard and Northern Pintail will. We used information provided by refuge staff to determine when and how quickly foods in each habitat type became available. We set foods in permanently flooded wetlands and unharvested grain fields as 100% available at the beginning of our modeling window (September 1 interval). Seasonal wetlands began flooding during the 15 September interval and filled at a constant rate until the 1 January interval when all were filled while grain crops that are to be harvested are assumed to be harvested by September 15. Potatoes became available starting October 1 as harvesting is initiated during the October 1 interval and proceeds at a steady rate until all fields are harvested by the November 1 interval.

Food Densities in TLNWR and LKNWR Habitats.-- We determined food abundance in wetland habitats at TLNWR and LKNWR as part of this study (Chapter 3). We used estimates of food abundance in harvested agricultural crops and pastures as reported by Kapantais et al. (2003). We sampled barley, oats, wheat, and potatoes shortly after harvest in fall, while pasture was sampled in spring. We obtained biomass estimates for unharvested barley, oat, and wheat fields from Dr. Harry Carlson at the University of California's Intermountain Research and Extension Office in Tule Lake (Table 4-2). Waterfowl abandon feeding in habitats before all food is exhausted because the costs of continuing to forage on a diminishing resource exceeds energy gained; this value is called the giving-up-density or foraging threshold (Nolet et al. 2006). For example, Mallards feeding in dry fields in Texas reduced corn densities to 13.2 lbs/acre before abandoning

Table 4-1. Habitat composition (acres) at Tule Lake and Lower Klamath National Wildlife Refuges during 2005.

Habitat Type	Refuge	
	Lower Klamath	**Tule Lake**
Seasonal Wetlands		
Early Succession	4,834	0
Late Succession	11,280	155
Permanent Wetlands		
Submerged Aquatic Veg.	7,355	11,539
Robust Emergent Veg.	1,839	3,030
Harvested Grains	6,534	8,471
Standing Grains	1,057	249
Harvested Potatoes	0	2,703
Green Browse	2,018	3,405
Total Habitat	**34,917**	**29,552**

Table 4-2. Food densities from agricultural and wetland habitats at Lower Klamath and Tule Lake NWRs. Agricultural, seasonal wetland, and permanent wetland food density estimates are reduced by a foraging threshold of 13.2, 30.8, and 44 lbs/acre, respectively.

Habitat Type	Refuge	
	TLNWR (lbs/acre)	**LKNWR (lbs/acre)**
Harvested Potatoes[a]	437	--
Green Forage (Pasture) [a]	176	176
Harvested Grain[a]		
Barley	77	77
Oats	157	156
Wheat	19	42
Weighted Mean[b]	41.9	56.0
Unharvest Grain[c]		
Barley	4,960	4,960
Oats	4,464	--
Wheat	5,952	--
Weighted Mean	5,675	4,960
Wetlands[d]		
Seeds-Early Succession Seasonal Wetlands	875	875
Seeds-Late Succession Seasonal Wetlands	489	489
Spring Invertebrates - All Wetlands	9	9
Roots / Tubers- Permanent Wetlands	49.4	218
Leafy Vegetation- Permanent Wetlands	121.7	214

[a] From Kapantais et al. 2003.
[b] Mean value that reflects the proportional contribution of each crop type to the category total
[c] Harry Carlson, University of California, Research and Extension Office, Tule Lake, California
[d] Data from Chapter 3

fields (Baldassarre and Bolen 1984) and waterfowl abandon rice fields in the Mississippi Alluvial Valley around 50kg/ha (Rutka et al. in review). Consequently, we adjusted our biomass estimates by subtracting published estimates of giving up densities. For grains, we subtracted 13.2 lbs/acre (Baldassarre and Bolen 1984); for seed resources in seasonal wetlands we subtracted 30.8 lbs/acre (Naylor 2002); and for tubers and green foliage in permanent wetlands we subtracted 44 lbs/acre (Reinecke et al. 1989). We report food density data in pounds per acre in this chapter, rather than kg/ha, because this report is intended to be shared with agricultural producers in the Klamath region and lbs/ac is the metric they use when discussing crop yields.

Nutritional Quality of Foods.-- We used data from published sources for estimates of the nutritional value for specific agricultural foods (Table 4-3). When the TME value of a specific food was not known, we used a value for a similar food type. When a comparable species was not available, we estimated TME using a regression relationship between TME value and the proximate composition of a food (Petrie et al. 1998).

Because so little is known about the TME value of specific aquatic invertebrates, we used a single value for this group. In contrast, the seeds of moist soil plants are known to vary considerably in nutritional quality. To estimate the energy content for seeds in early and late successional seasonal wetlands, we calculated a weighted mean by multiplying the TME value for each plant by its proportional contribution to the total seed biomass in the unit (from Chapter 3). We then summed the weighted values for all species in a unit to get the composite TME value for each unit and calculated the mean TME value for units in each seasonal wetland category. We used TME estimates from Chapter 3 as well as those from Petrie et al. (1997) and Checkett et al. (2002). TME values were not available for the seeds of all plants that occurred in our samples. We used estimates from other species in the same genus if they were available (e.g., the TME value for *Rumex crispus*, 2.68 kcals/g was applied to the seeds for all *Rumex* species). For seeds of species collected on the #45 screen from the core samples (Chapter 3), we used a TME value of 2.6 kcals/g, the mean of the species that made up the bulk of the small seeds (*Amaranthus* and *Chenopodium* sp.). For all other seeds we used a TME value of 2.0 kcals/g, the mean for all moist soil seed with known TME values. Using this

Table 4-3. True metabolizable energy (TME) of waterfowl foods at TLNWR and LKNWR.

Food Type or Category	**TME Value (kcal/g)**
Grains[1]	3.0
Potatoes[2]	4.0
Alfalfa Pasture[3]	2.4
Seasonal Wetland Seeds (early succession)[4]	2.4
Seasonal Wetland Seeds (late succession)[4]	1.6
Leafy Vegetation[3]	2.0
Roots / Tubers[5]	2.5
Aquatic invertebrates[6]	2.5

[1] from Sugden (1971)
[2] based on proximate composition (Petrie et al. 1998).
[3] from Petrie et al. (1998)
[4] These metabolizable energy estimates were combined with published TME values of other moist-soil seed resources to generate an average TME value for seeds in early and late succession seasonal wetlands (Checkett 2002).
[5] based on foods of similar proximate composition
[6] from Purol (1975)

Table 4-4. Food types used by waterfowl guilds to meet their daily energy demands on LKNWR and TLNWR.

Guild	Standing Grain	Harvested Grain	Harvested Potatoes		SW Seeds	PW Leafy Vegetation	PW Roots and Tubers
Dabbling Ducks	X	X			X		
Diving Ducks							X
Geese	X	X	X	X			
Swans							X
Coots						X	

X – Indicates foraging habitats that are assumed to be used by a waterfowl guild
SW- Seasonal wetland
PW- Permanent Wetland

approach, we estimated the average TME value was 2.38 kcal/g in early successional wetlands and 1.59 kcal/g in late successional wetlands (Table 4-3).

Percentage of a bird's daily energy needs met on-site and the habitats or food types each guild can use to satisfy its daily energy requirements.-- We used information in the published literature and observations of refuge staff to determine what percentage of each guilds daily energy needs must be met on site and the habitats and food types each guild was allowed to use to satisfy their daily energy needs (Table 4-4). We required that diving duck and swans satisfy 100% of their energy needs by foraging on the tubers of submerged aquatic vegetation. The diet of diving ducks differ, but we felt this constraint was appropriate given Canvasback was the most common species in our diver guild. Because of similar food habits and on-site requirements, we combined diving ducks and swans in our modeling even though we generated separate population objectives in Chapter 2. For coots, we required they meet 100% of their energy needs by feeding on the leafy vegetation of submerged aquatic plants, which constrained them to permanent wetlands. We assumed leafy plant material was gone after 1 November (because of senescence); therefore, coot food supplies were effectively zero after this date. We required that geese forage on harvested and unharvested grain crops, (regardless of flooding status), harvested potatoes and pasture (alfalfa). However, because green forage consumption by geese at TLNWR and LKNWR largely occurs during spring migration (D. Mauser personal observation), we assumed that geese only foraged in pasture from 1 March through 15 April.

We required dabbling ducks to feed on seeds and invertebrates in seasonal wetlands and on harvested and unharvested, flooded or unflooded, grain crops. The exception was Gadwall. Although we included Gadwall in the dabbler foraging guild when generating population objectives in Chapter 2, their feeding habitats are similar to coots, both feeding almost exclusively on leafy plant material in permanent wetlands. Thus, we required that 100% of their daily energy needs be met by feeding on leafy vegetation from the 1 September to the 1 November period. During that period, we modeled them separately from other dabblers. After 1 November, we allowed Gadwall to feed on the same foods as other dabblers and included them in the larger dabbling duck guild. Gadwall were a small fraction of the dabbler guild in general, particularly in winter (Figures 2-11, 2-12).

The extent we required each guild to meet their energy needs on the refuges varied. We required diving ducks, swans, and coots to meet 100% of their needs on refuge for every model. Similarly, we required Gadwall to meet 100% of their needs on refuge up to 1 November. All species of geese and most species of dabbling duck will feed on surrounding private lands, but the extent they require private lands to meet their needs was unknown. We required that geese and dabbling ducks meet from 75-100% of their daily energy needs on refuge. Our decision to use 75% as a minimum reflected a desire by refuge staff to reduce private crop and pasture depredation and provide a higher proportion of the spring diet from refuge habitats.

Model Simulations

We first used TRUEMET to run two models for each refuge: Model 1) current habitat conditions and recent waterfowl populations and Model 2) current habitat conditions and waterfowl population objectives outlined in Chapter 2. We then evaluated five additional models (Models 3-8) that represented several potential management alternatives designed to alleviate food resource deficits identified in Model 2. Because each refuge operates under a unique set of guidelines and infrastructure, we created unique alternative management scenarios for each refuge.

<u>Model 1: Current Conditions</u>

Our first set of simulations compared energy supply based on habitat composition in 2005 and demand based on mean waterfowl population size from surveys conducted 1990-1999. We required all foraging guilds to meet 100% of their daily energy needs from refuge food sources. These simulations provided insight into how well TLNWR and LKNWR can meet the needs of current waterfowl populations in isolation of surrounding private lands.

Outcome.-- Lower Klamath provides enough energy to meet the demands of current diving duck and swan populations (Figure 4-1). Supply exceeded demand considerably all the way through mid-April suggesting additional birds could be supported; this is consistent with the increasing trend in diver and swan abundance since the 1970s. Carrying-capacity was sufficient despite the fact our estimate of food abundance was likely conservative because we did not allow swans to forage in flooded agricultural fields. Refuge staff have observed this behavior in January and February. Foods for geese were close to meeting fall and winter needs, but were insufficient to meet the large goose populations stopping in the region during spring migration (Figure 4-2). Dabbler foods are exhausted by early March, but come fairly close to meeting current population needs (Figure 4-3). Food was sufficient for coots and Gadwall from the 1 September to 1 November period (Figures 4-4 and 4-5). Considering we required birds to meet 100% of their daily energy demands on-refuges, an assumption that is surely false for many dabblers and geese, habitats at Lower Klamath NWR appear to be meeting the energy needs of current waterfowl populations.

Unlike LKNWR, energy supplies at TLNWR for diving ducks and swans were exhausted by mid-February (Figure 4-6) and food supplies for dabbling ducks run out earlier than LKNWR, being exhausted by early December (Figure 4-8). The relatively poor dabbler habitat at TLNWR compared to LKNWR is consistent with declines in dabbler abundance at TLNWR since the 1970s while dabbler populations at LKNWR have remained steady (Chapter 2). Like LKNWR, food supplies for geese largely meet population demands in fall and winter, but were insufficient to meet spring needs (Figure 4-7). Food resources for Gadwall and coots are sufficient to support current populations through 1 November (Figures 4-9 and 4-10).

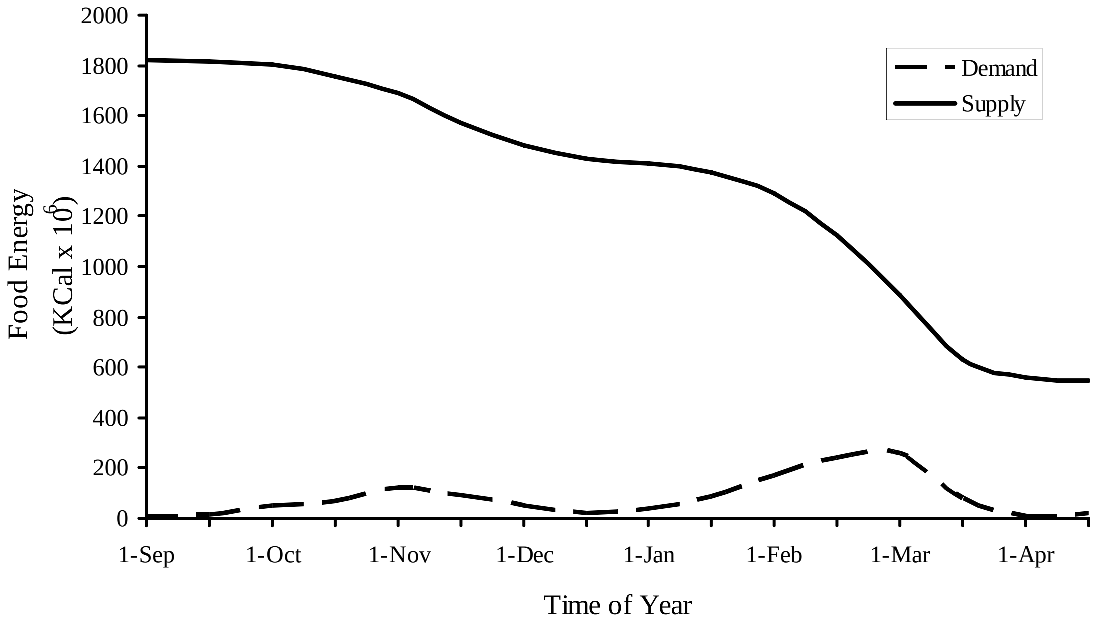


Figure 4-1. Population energy demand vs. food energy supplies for diving ducks and swans (mean 1990s populations) at LKNWR under simulated 2005 habitat conditions.

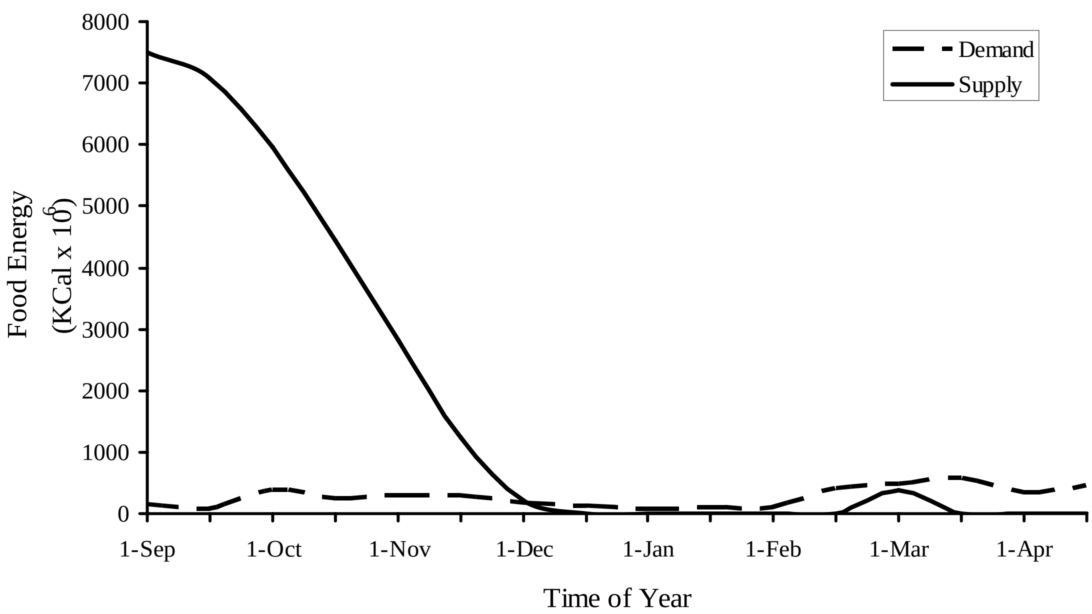


Figure 4-2. Population energy demand vs. food energy supplies for geese (mean 1990s populations) at LKNWR under simulated 2005 habitat conditions.

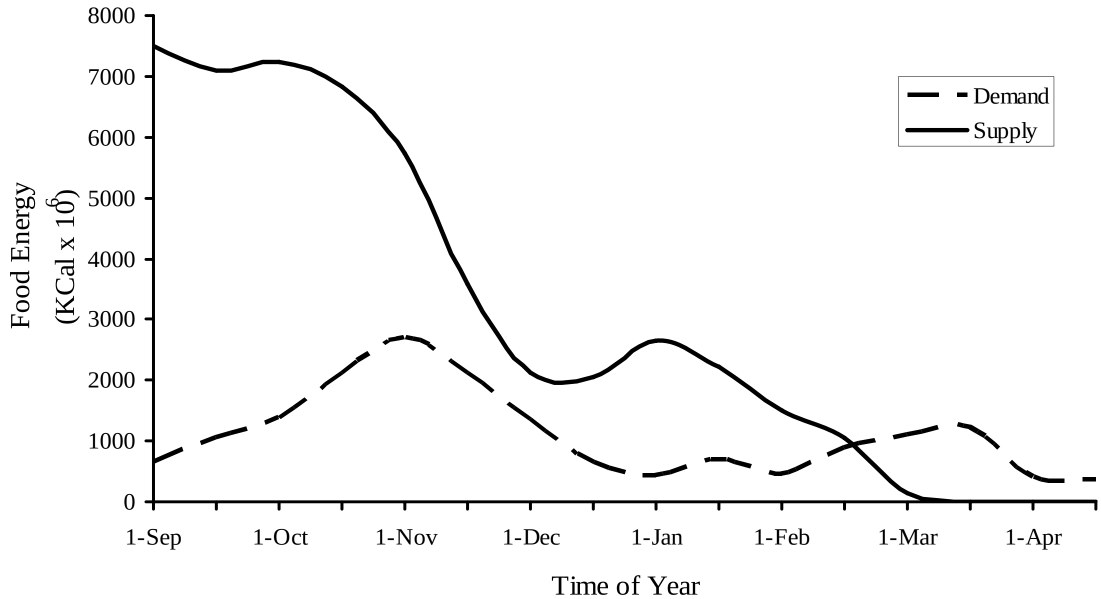


Figure 4-3. Population energy demand vs. food energy supplies for dabbling ducks (mean 1990s populations) at LKNWR under simulated 2005 habitat conditions.

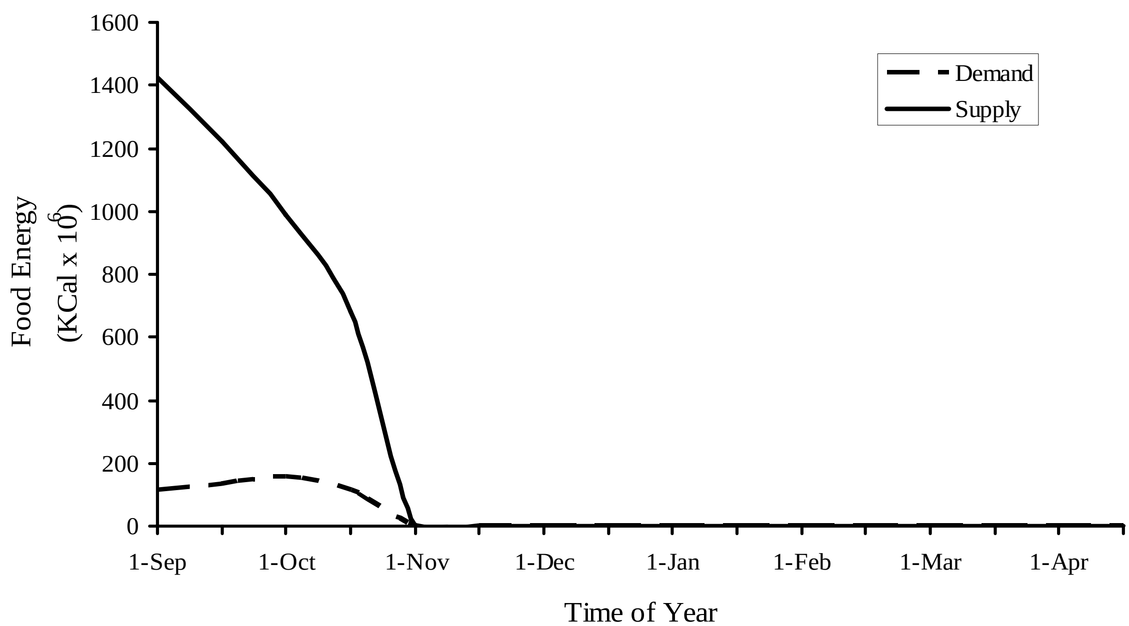


Figure 4-4. Population energy demand vs. food energy supplies for gadwall (mean 1990's populations) at LKNWR under simulated 2005 habitat conditions.

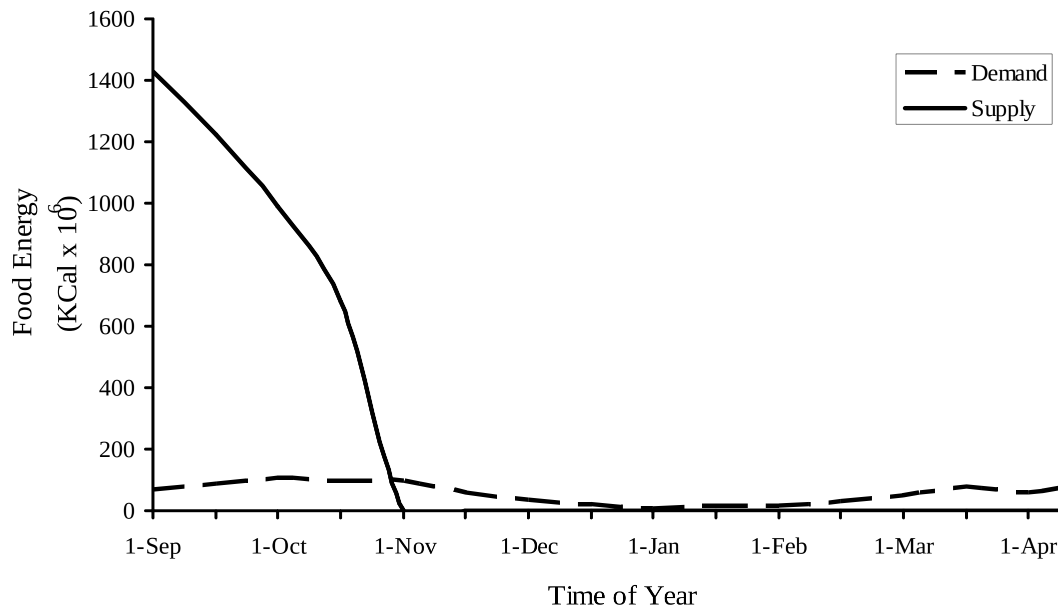


Figure 4-5. Population energy demand vs. food energy supplies for coots (mean 1990's populations) at LKNWR under simulated 2005 habitat conditions.

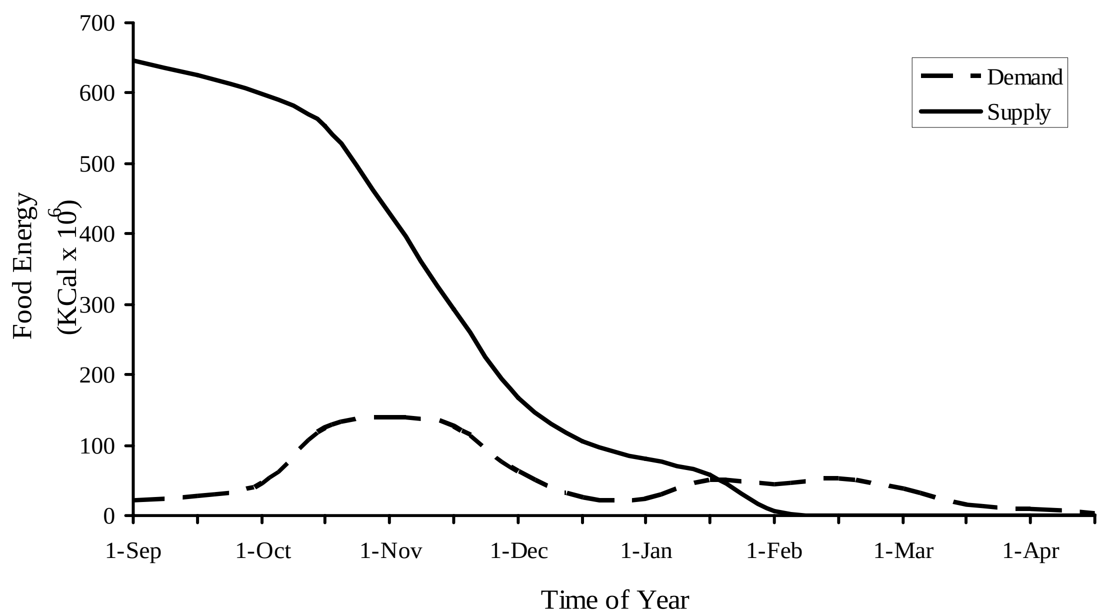


Figure 4-6. Population energy demand vs. food energy supplies for diving ducks and swans (mean 1990's populations) at TLNWR under simulated 2005 habitat conditions.

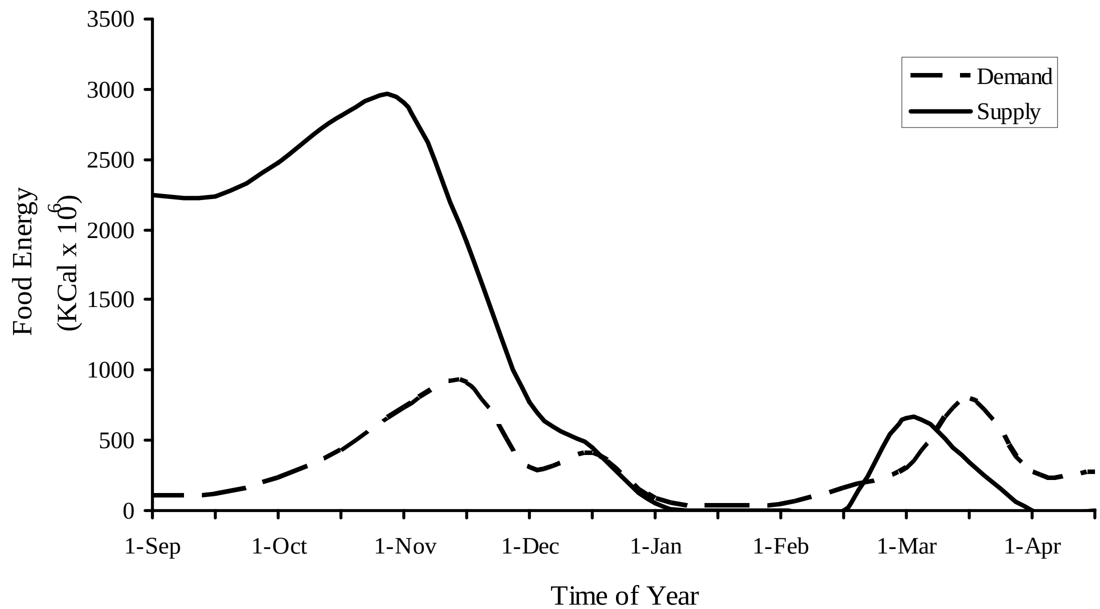


Figure 4-7. Population energy demand vs. food energy supplies for geese (mean 1990's populations) at TLNWR under simulated 2005 habitat conditions.

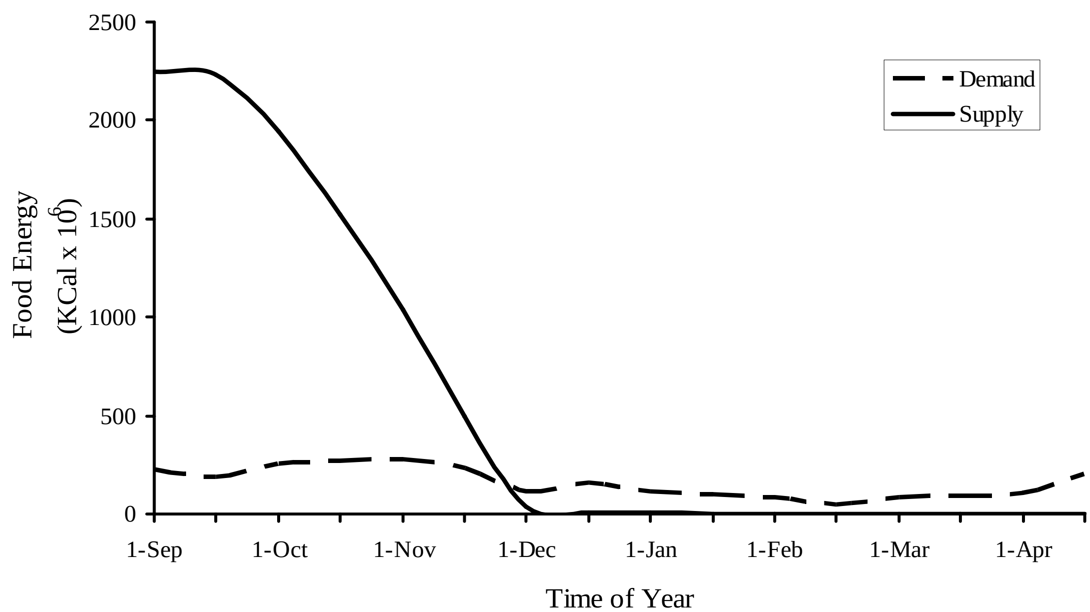


Figure 4-8. Population energy demand vs. food energy supplies for dabbling ducks (mean 1990's populations) at TLNWR under simulated 2005 habitat conditions.

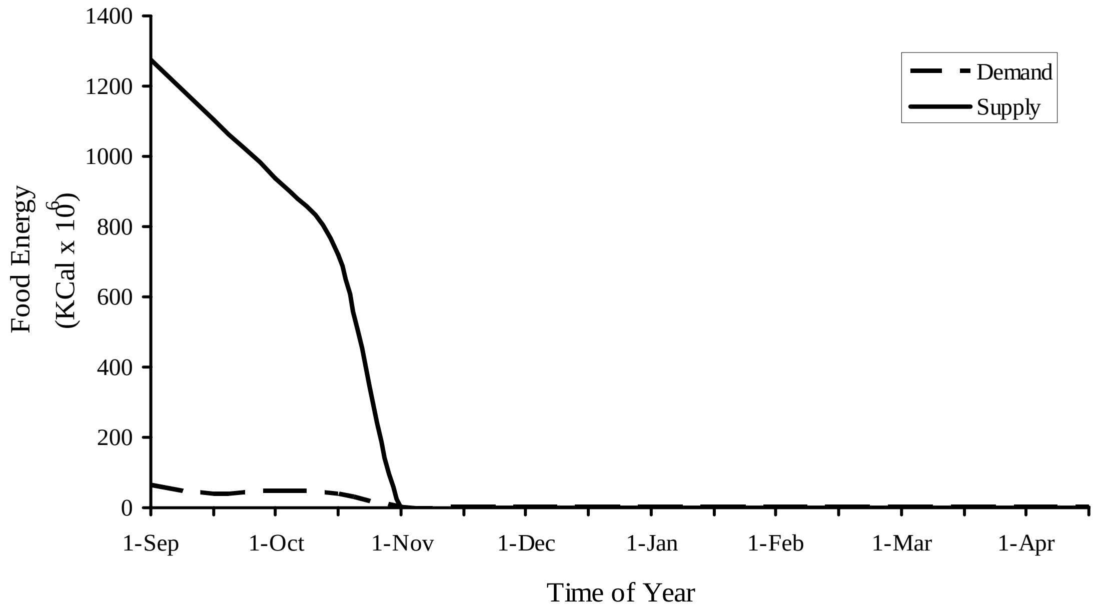


Figure 4-9. Population energy demand vs. food energy supplies for gadwall (mean 1990’s populations) at TLNWR under simulated 2005 habitat conditions.

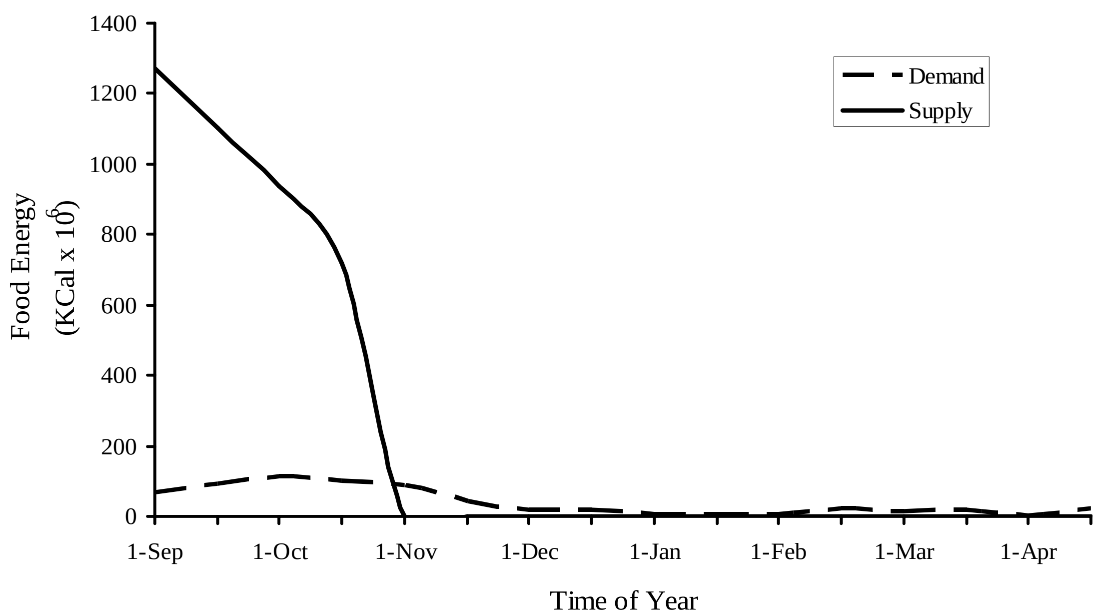


Figure 4-10. Population energy demand vs. food energy supplies for coots (mean 1990’s populations) at TLNWR under simulated 2005 habitat conditions.

Model 2: Ability to Meet Waterfowl Population Objectives

Our second set of simulations examined how well existing habitat conditions at TLNWR and LKNWR could meet waterfowl needs given refuge population objectives established in Chapter 2. Rather than use the mean population count like scenario one, we used the 75th percentile, a more conservative number that recognized the desire of the refuge to meet bird needs in greater than 50% of years. This scenario also allowed 25% of goose and dabbler energy needs to be met off refuge.

Outcome.-- Scenario 2 indicated deficiencies in energy supplies for one or more taxa at each refuge. Current habitats at LKNWR provided sufficient food energy to meet population objectives for swans and divers (Figure 4-11) and dabbling ducks (Figure 4-12) all season and gadwall (Figure 4-13) and coots (Figure 4-14) from 1 September to 1 November. However, LKNWR could not support goose population objectives, being exhausted prior to the March 1 interval, 6 weeks before the end of our modeling window (Figure 4-15).

At TLNWR, food resources were adequate to meet the energy needs of diving ducks and swans (Figure 4-16) and gadwall (Figure 4-17) and, but were insufficient to meet the needs of dabbling ducks (Figure 4-18), and geese (Figure 4-19). Dabbler foods were exhausted early in fall, before traditional peak migration in November. Goose needs were met through most of fall and winter but not spring. Although leafy vegetation met coot needs prior to 1 November at TLNWR (Figure 4-20), survey data indicate coots persist at both Tule Lake and Lower Klamath longer than would be predicted. This may reflect persistence of submerged aquatic vegetation beyond 1 November or coot use of other food sources.

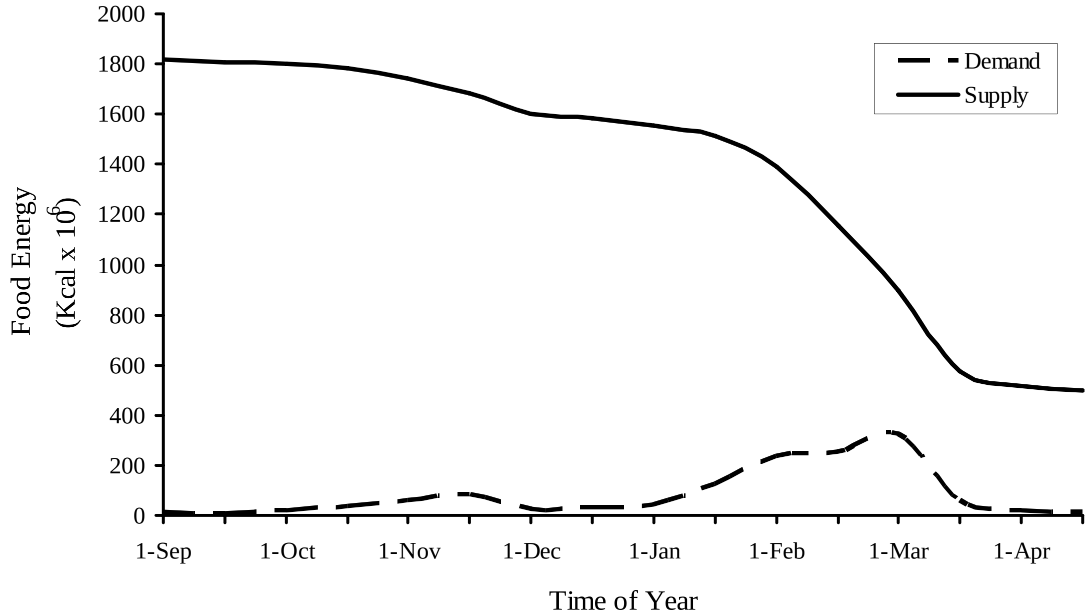


Figure 4-11. Population energy demand vs. food energy supplies (simulated 2005 habitats) for diving ducks and swans at LKNWR relative to refuge population objectives.

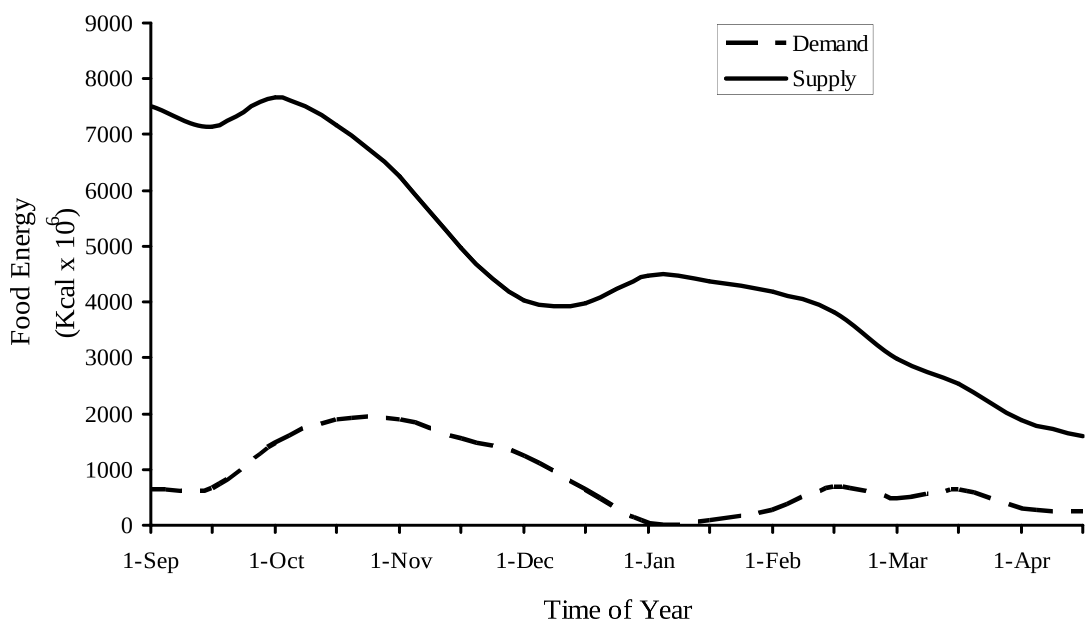


Figure 4-12. Population energy demand vs. food energy supplies (simulated 2005 habitats) for dabbling ducks at LKNWR relative to refuge population objectives.

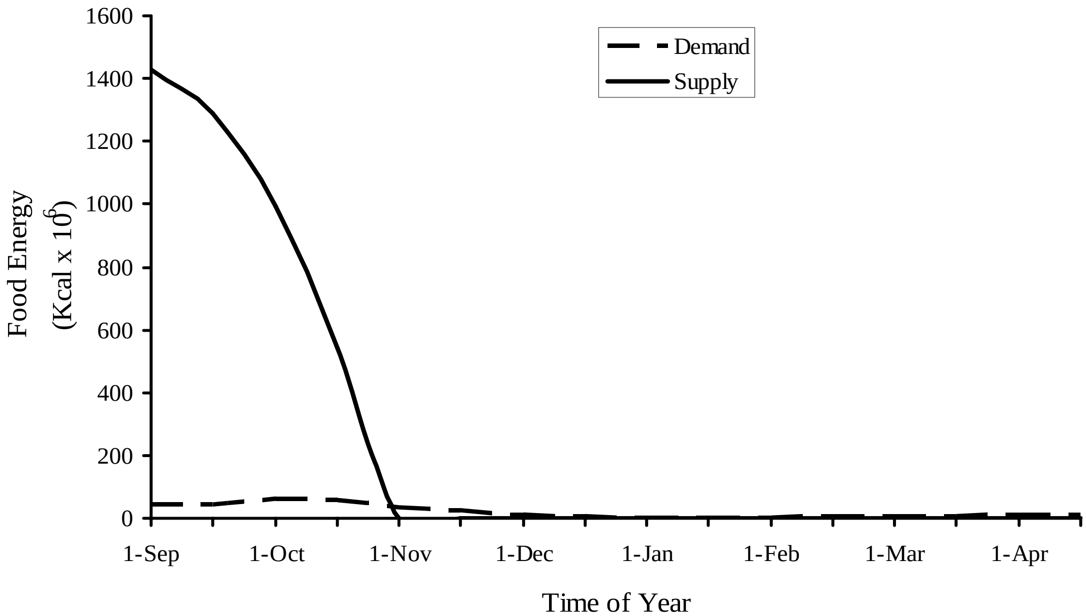


Figure 4-13. Population energy demand vs. food energy supplies (simulated 2005 habitats) for gadwall at LKNWR relative to refuge population objectives.

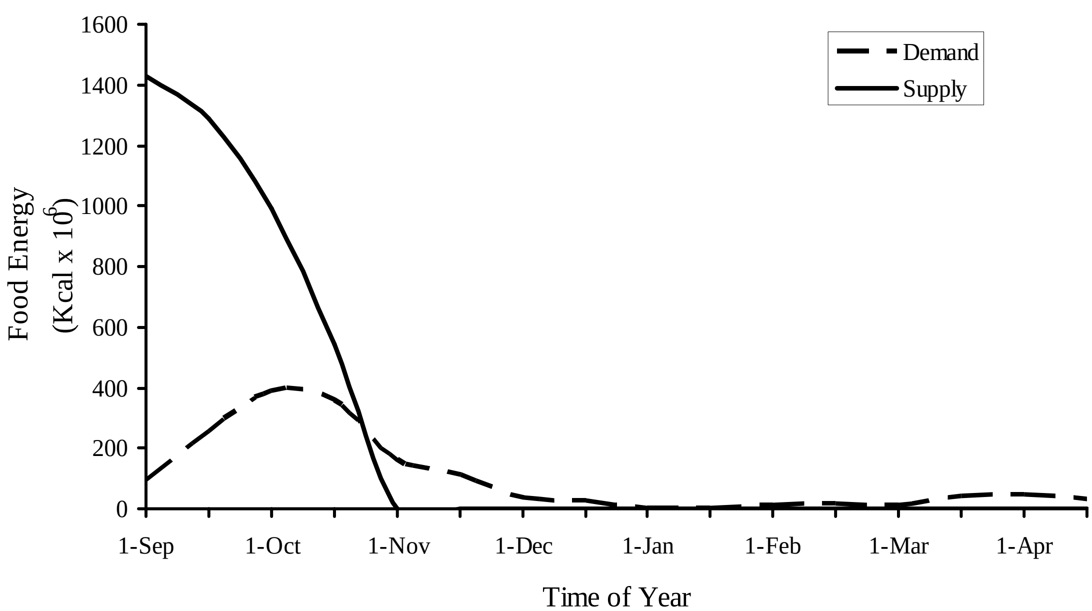


Figure 4-14. Population energy demand vs. food energy supplies (simulated 2005 habitats) for coots at LKNWR relative to refuge population objectives.

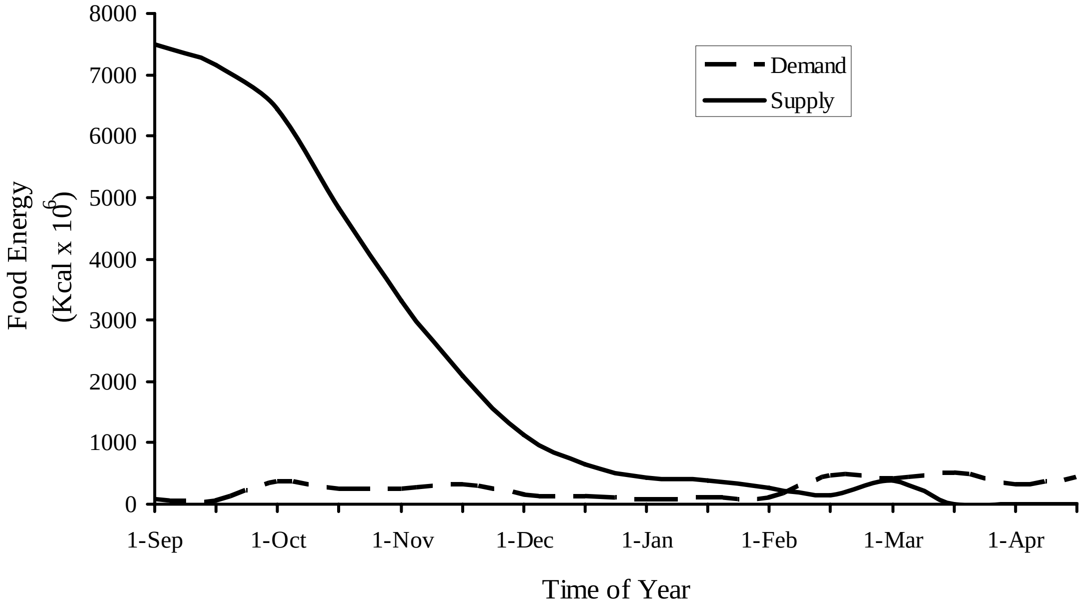


Figure 4-15. Population energy demand vs. food energy supplies (simulated 2005 habitats) for geese at LKNWR relative to refuge population objectives.

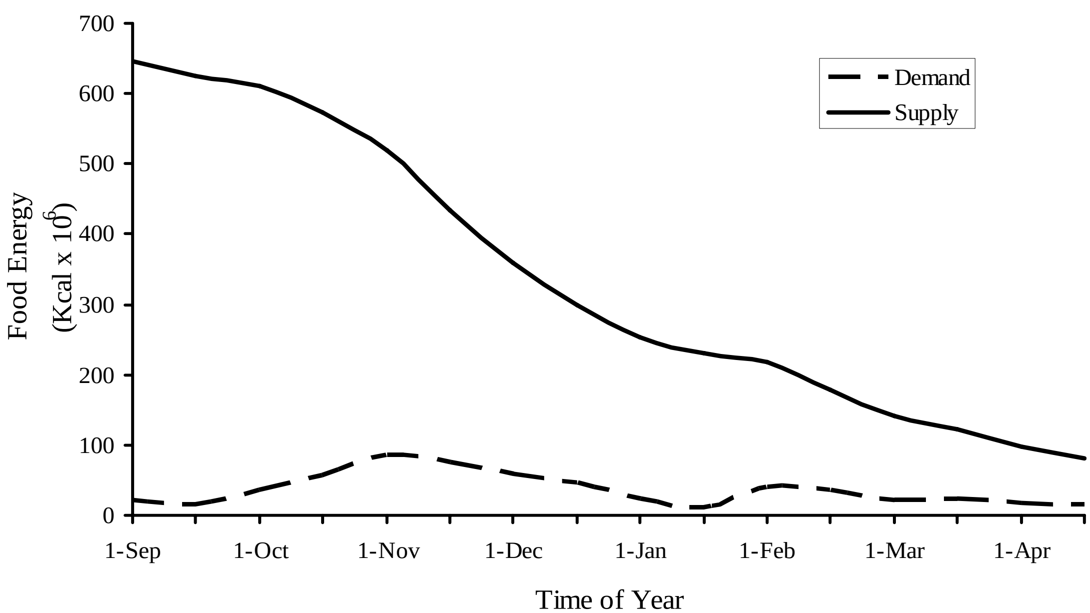


Figure 4-16. Population energy demand vs. food energy supplies (simulated 2005 habitats) for diving ducks and swans at TLNWR relative to refuge population objectives.

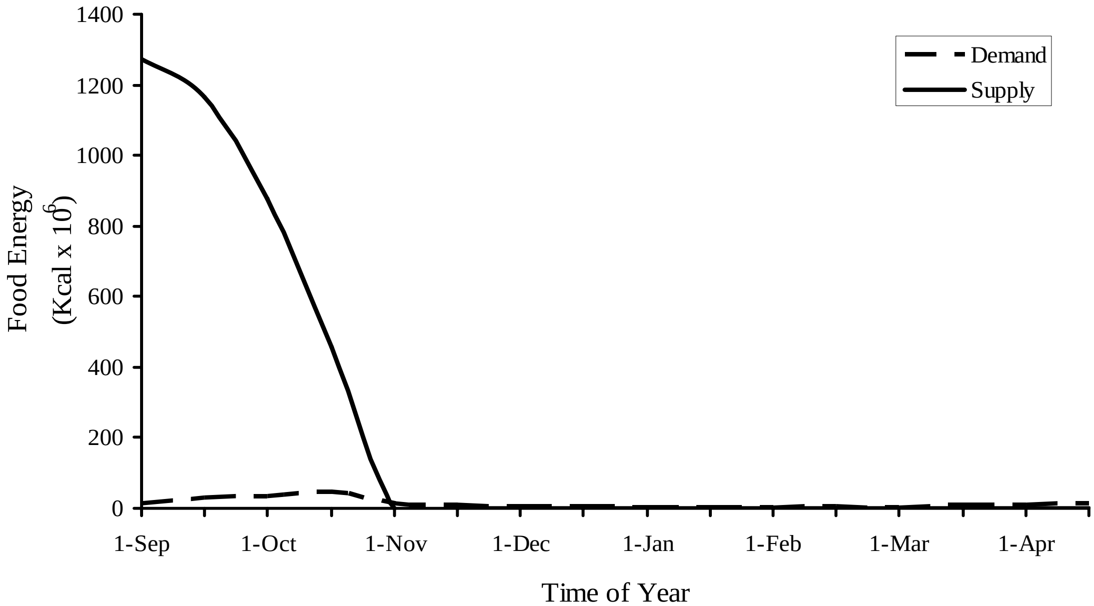


Figure 4-17. Population energy demand vs. food energy supplies (simulated 2005 habitats) for gadwall at TLNWR relative to refuge population objectives.

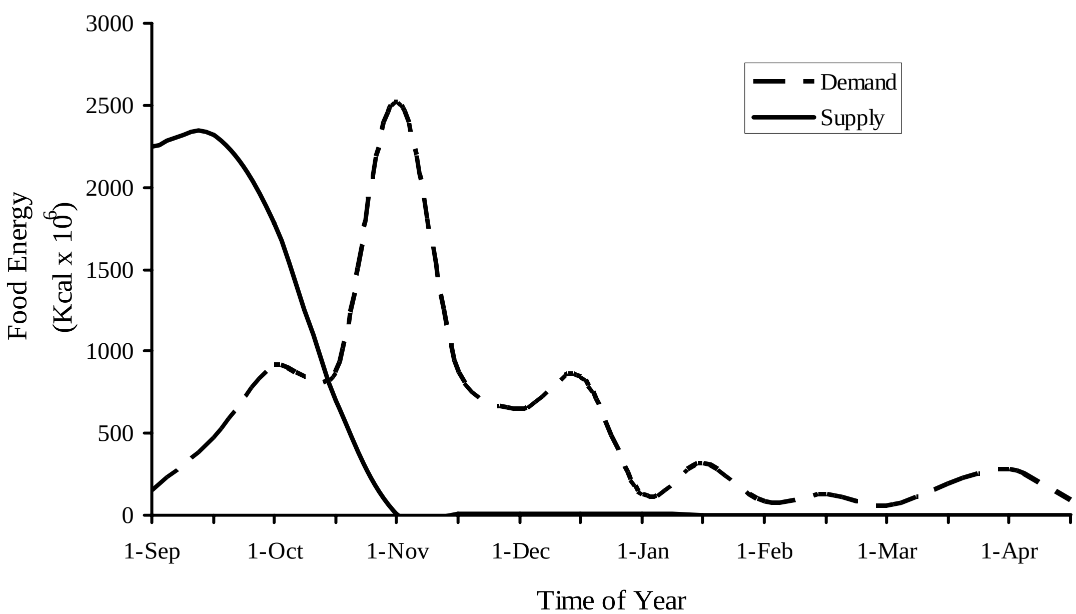


Figure 4-18. Population energy demand vs. food energy supplies (simulated 2005 habitats) for dabbling ducks at TLNWR relative to refuge population objectives.

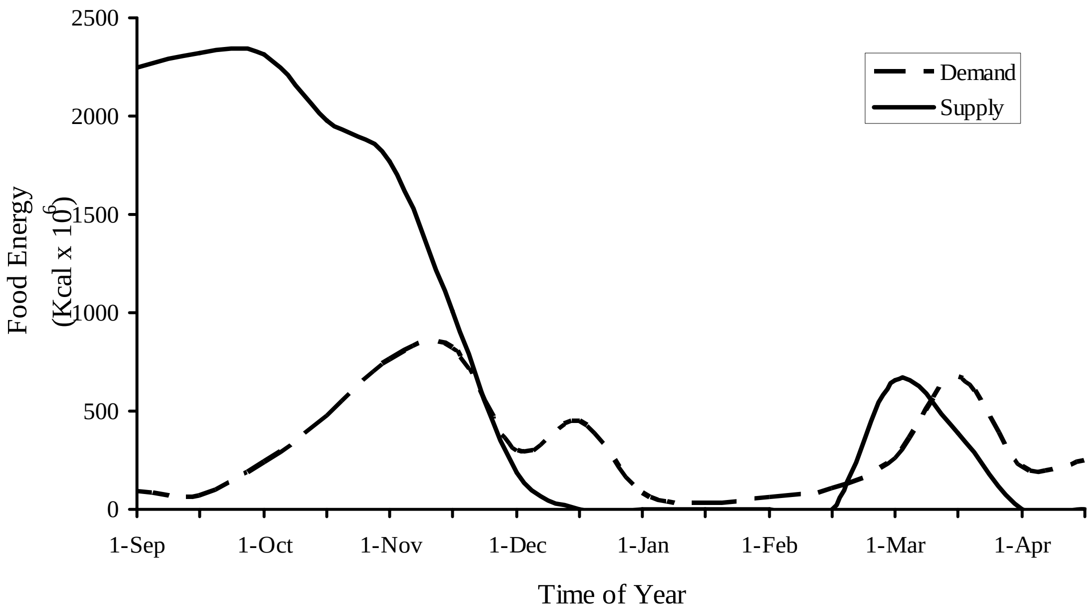


Figure 4-19. Population energy demand vs. food energy supplies (simulated 2005 habitats) for geese at TLNWR relative to refuge population objectives.

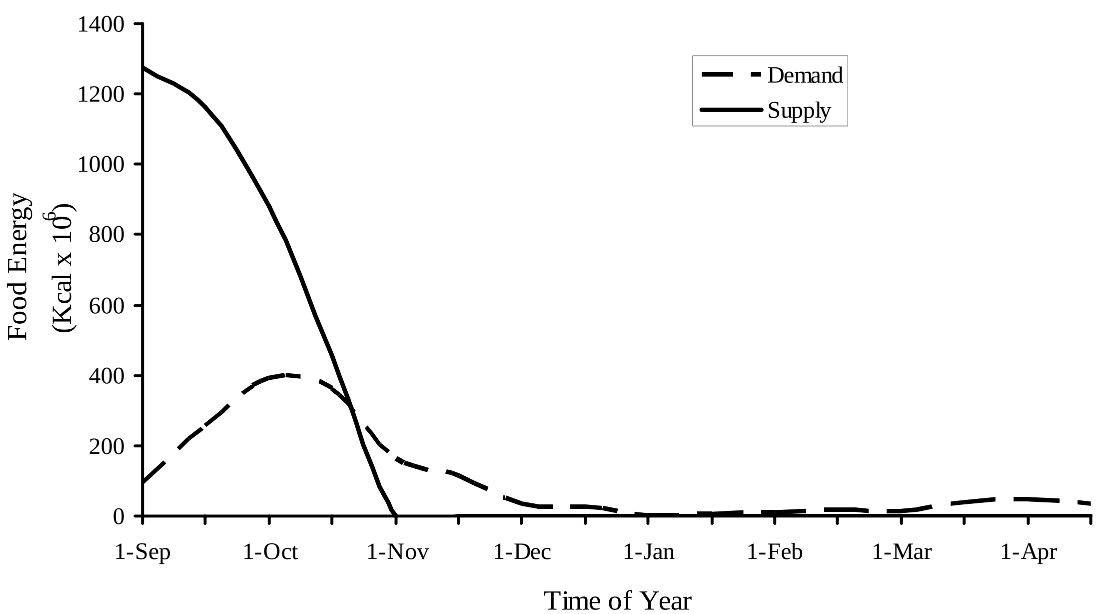


Figure 4-20. Population energy demand vs. food energy supplies (simulated 2005 habitats) for coots at TLNWR relative to refuge population objectives.

Model 3: Meeting LKNWR goose needs

Food supplies for geese at LKNWR were adequate until late winter (Figure 4-15). We asked how many additional acres of unharvested grain and green browse would be needed to meet goose energy demands on LKNWR? Increasing unharvested grain is the most land-efficient option for increasing food for geese in fall and winter (greatest energy gain for least amount of land) while increasing green browse improves foraging conditions for geese in spring, the period when food is currently most limiting. In essence, this scenario reflects a modification in the refuge farming program that left more standing grain and increased acreage of alfalfa or pasture. To answer this question, we incrementally increased the acreage of unharvested grain to meeting winter energy needs and green browse to meet spring energy needs. These increases were offset by a reduction in the amount of harvested grain. In this scenario, acres devoted to wetland habitats were not changed, protecting those acres for waterbirds dependent on wetlands. Altering the ratio of harvested and unharvested grain affects dabbling ducks because they utilize these habitats as well. Therefore, we modeled the affect of this scenario on both dabblers and geese.

Outcome.-- To meet goose energy needs in winter and spring, unharvested grain acreage would need to expand from 1,000 to 1,500 acres and green browse would need to increase from 2,000 to 4,000 acres (Figure 4-21). This results in a reduction of harvestable acres from 6,500 to 4,000. This scenario also increases dabbler energy supply considerably above projected need (Figure 4-22).

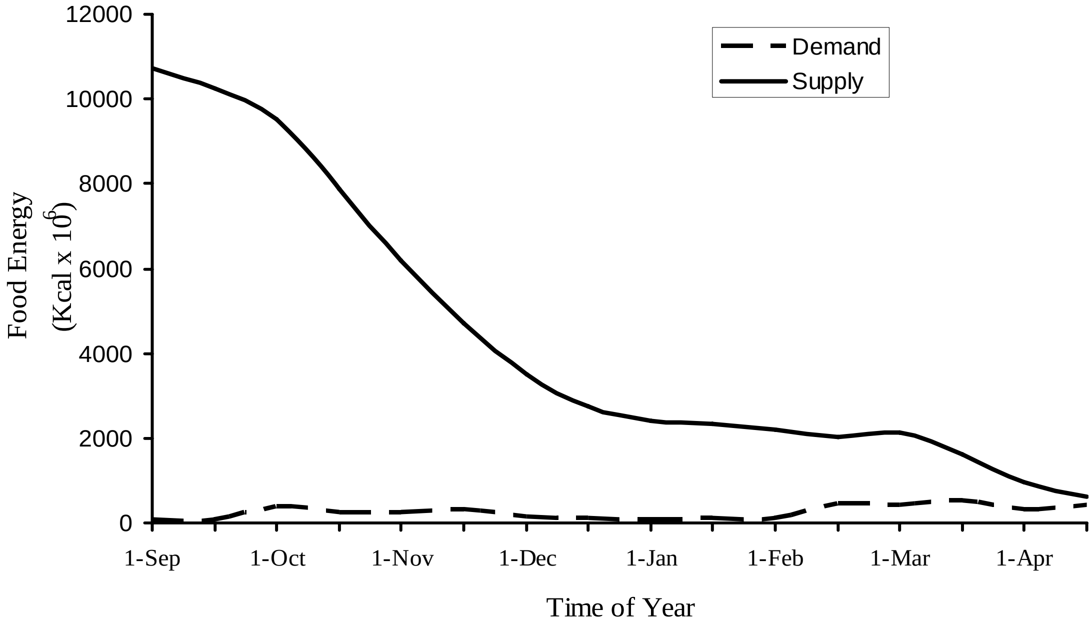


Figure 4-21. Population energy demand vs. food energy supplies for geese at LKNWR after increasing standing grain by 500 acres and green browse by 2,000 acres.

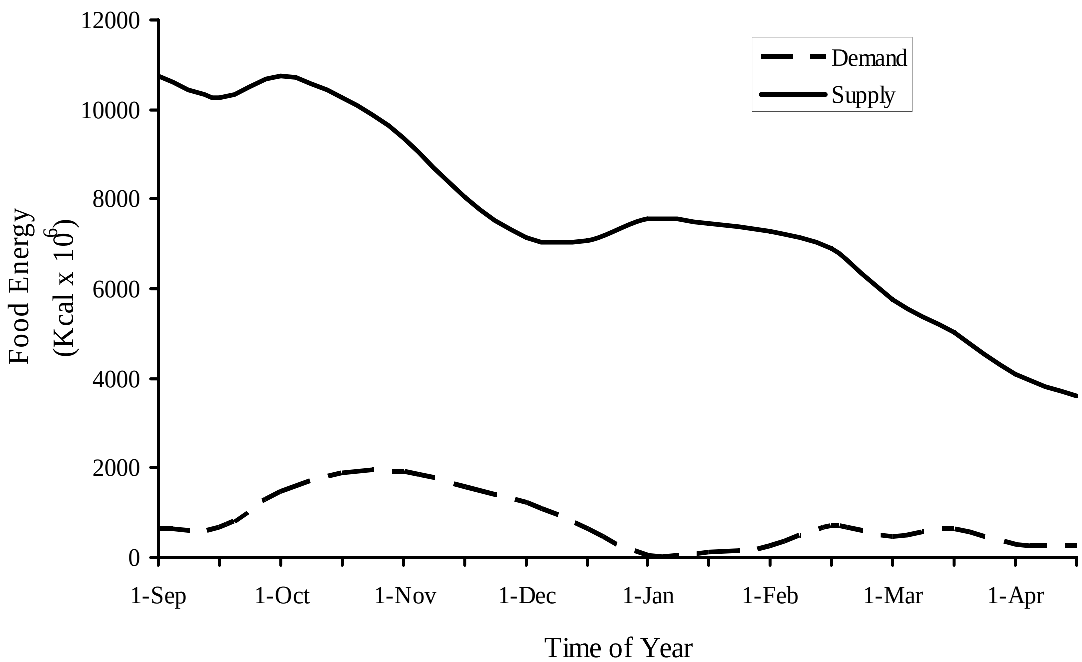


Figure 4-22. Population energy demand vs. food energy supplies for dabbling ducks at LKNWR after increasing standing grain by 500 acres and green browse by 2,000 acres.

Model 4: The “Big Pond” (LKNWR)

Our current conditions model assumed that flooding of seasonal wetlands began in early September and progressed until all wetlands were full by 1 January. This pattern represents the historic management hydroperiod at LKNWR. However, chronic water shortages during summer and fall during the last 15 years have made this flooding schedule increasingly difficult to achieve. In an effort to deal with the possibility of long-term shortages in water availability during summer and early fall, the Refuge is exploring ways to capture water during winter and early spring, a time when water is typically in abundance.

One alternative, called the Big Pond Scenario (BPS), would create a 13,000 acre unit on the southern one-half of the Refuge. Management would focus on capturing water in winter and spring to fill the unit and allow levels to gradually recede during the summer and fall, essentially mimicking conditions on historic Lower Klamath Lake. It would require approximately 50,000 to 70,000 acre-feet of water to “fill” the unit and water depths would range from seven feet to inches at the margins. Preliminary hydrologic analysis indicates there is sufficient water in most years to fill the Big Pond. Even with no water deliveries in summer, the area would support large numbers of colonial nesting waterbirds as well as molting and breeding waterfowl. It is expected that approximately one-half of the surface area of the “Big Pond” would remain flooded during fall migration. Similar management on smaller areas of Lower Klamath NWR has provided an impressive habitat response and high waterbird use.

We used TRUEMET to understand the consequences of the BPS to foraging waterfowl by altering the composition of wetland habitat types on LKNWR. First we had to assign the 13,000 acres associated with the BPS to wetland categories. The hydroperiod for the BPS assumes that half (6,500 acres) of the BP draws down naturally between May and November as a result of evapotranspiration. Thus, we classified half of the BP as a seasonal wetland and the remaining half as permanent wetland. Half of the seasonal wetland component (3,250 acres) would occur at elevations high enough for moist soil plants to germinate and mature (i.e., water would draw down early enough). For these acres, we used food density equal to other LKNWR seasonal wetland habitats; however, because low lake levels will keep these areas dry in fall, we only made these acres available to foraging waterfowl beginning 1 March when flooding begins. We assumed flooding progressed in a linear fashion from 1 March until the BP is full on 15 April. For the remaining 3,250 acres of the seasonal wetland portion of the BP, we set waterfowl foraging value to zero.

We did not change the number of acres dedicated to agriculture, so all changes in habitat distribution came from existing wetlands acres. The total wetland acreage on LKNWR was 25,308 acres in 2005. After allocating 13,000 to the Big Pond Unit, we allocated the remaining acreage to seasonal wetlands. The final allocation resulted in little change in seasonal wetland acres but a significant decline in permanent wetland acres (Table 4-5).

We simulated how the BPS influenced energy supplies for dabblers, gadwall, divers and swans, and coots. We did not model geese because agricultural habitats were not influenced under the BPS and geese obtain their energy from the agricultural crops. The demand curves for all waterfowl guilds were the same as the Population Objectives model (Model 2).

Table 4-5. Acres dedicated to wetland habitat types during 2005 and under the Big Pond Scenario at Lower Klamath National Wildlife Refuge, California.

Wetland type	2005	Big Pond Scenario
Permanent wetland	9,194	6,500
Seasonal wetland	16,114	15,558
No feeding value[a]	0	3,250
Total	25,308	25,308

[a] The number of acres in the Big Pond Unit that will dry during summer but not produce moist soil plants

Outcome

The overall reduction in permanent wetlands under the BPS does negatively impact waterfowl guilds dependent on this habitat type. Resources for diving ducks and swans under the BPS appear to barely meet needs (Figure 4-23) while coot needs exceed refuge capacity earlier than our Population Objective model (Model 2; Figure 4-24). However, the BPS improves conditions for dabbling ducks (Figure 4-25). Delaying the availability of seasonal wetland plant foods on the Big Pond until spring does not compromise fall dabbler needs. Given this situation, delaying flooding until spring may result in higher quality spring habitats as fewer seeds will have been lost to decomposition during winter (Greer et al. 2007). Gadwall were relatively unaffected by the BPS (Figure 4-26). A summary of each model scenario and alternatives relative to LKNWR is provided in Table 4-6.

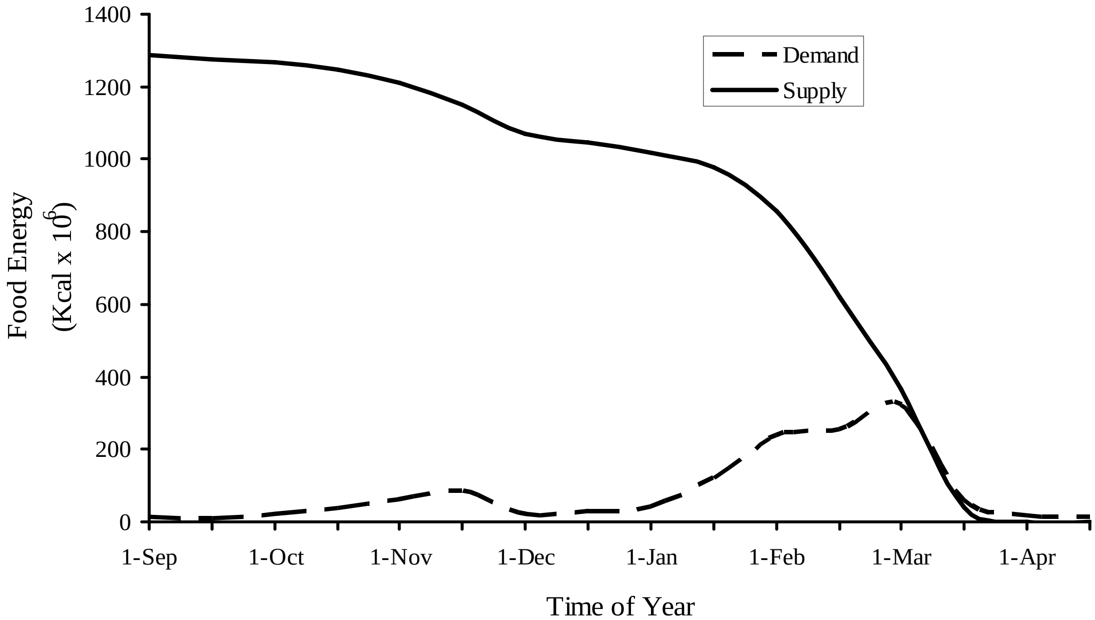


Figure 4-23. Population energy demand vs. food energy supplies for diving ducks and swans at LKNWR under habitat conditions outlined in Big Pond Scenario (Model 4).

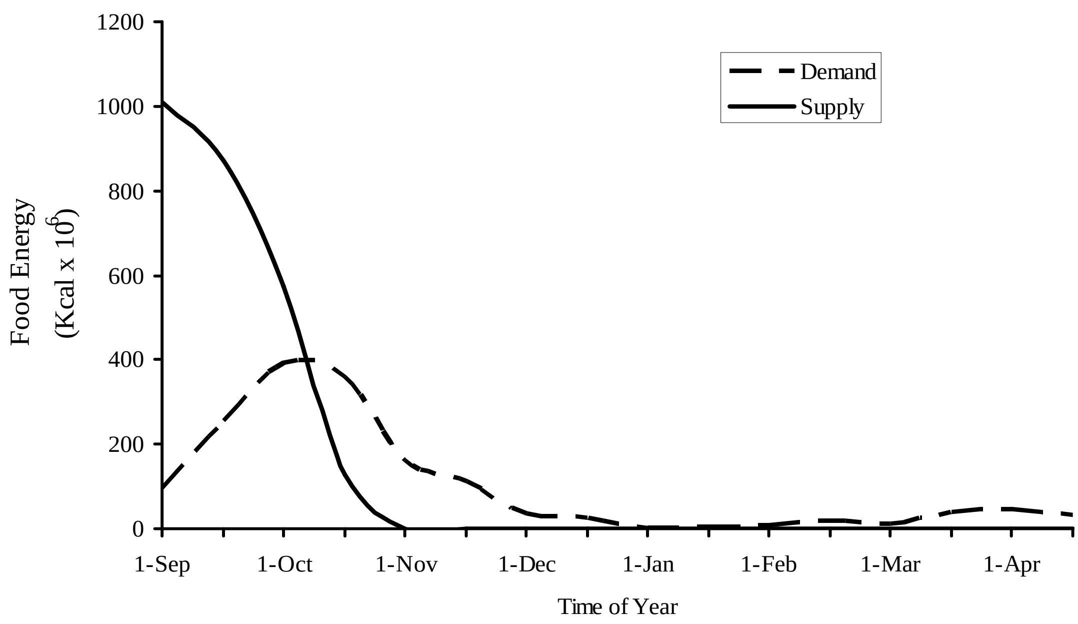


Figure 4-24. Population energy demand vs. food energy supplies for American Coots at LKNWR under habitat conditions outlined in Big Pond Scenario (Model 4).

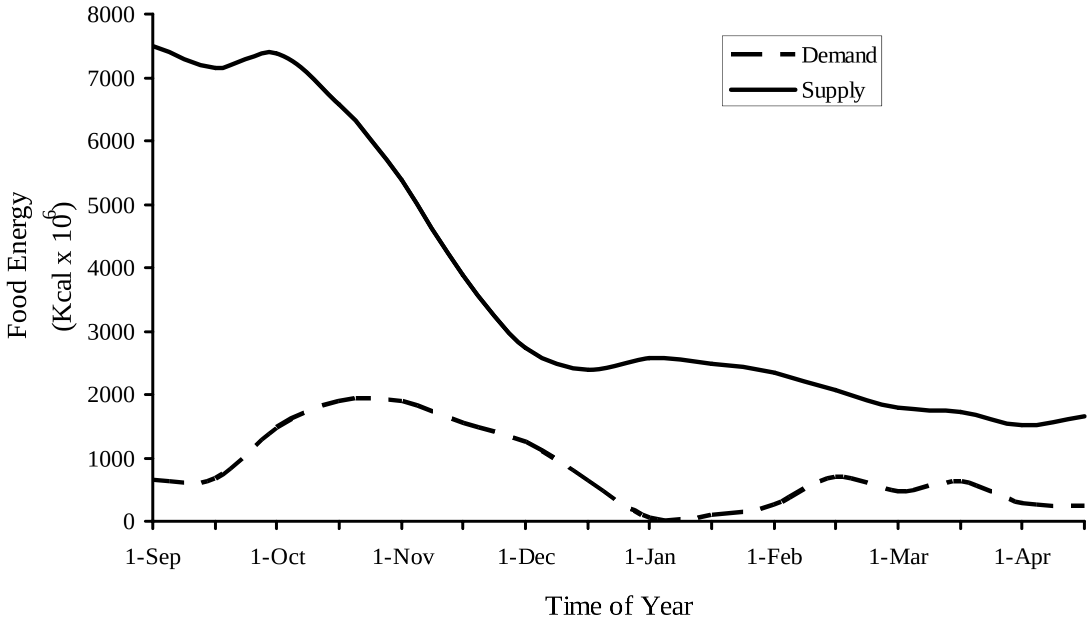


Figure 4-25. Population energy demand vs. food energy supplies for dabbling ducks at LKNWR under habitat conditions outlined in Big Pond Scenario (Model 4).

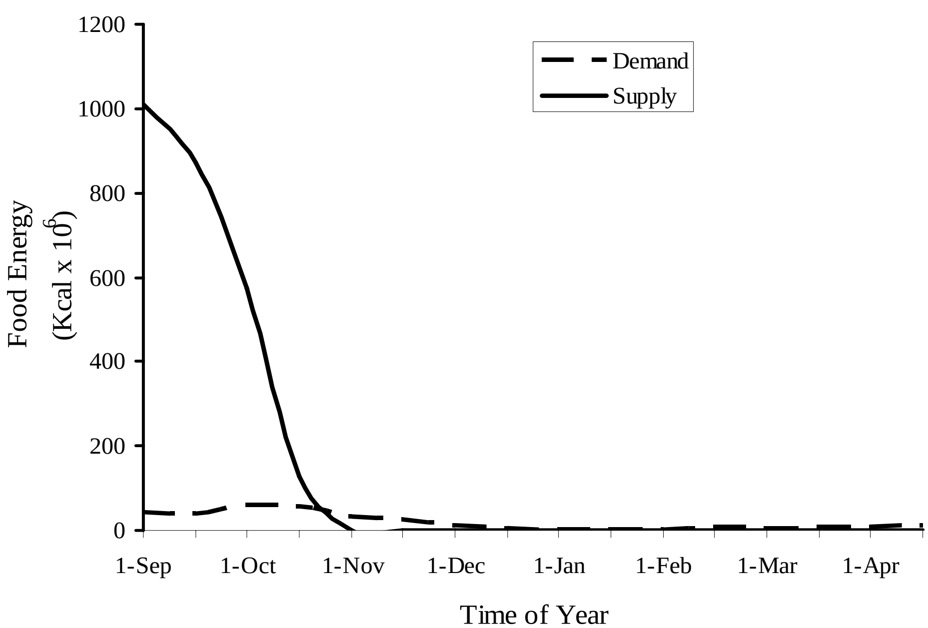


Figure 4-26. Population energy demand vs. food energy supplies for Gadwall at LKNWR under habitat conditions outlined in Big Pond Scenario (Model 4).

Model 5: Increased Standing Grain (TLNWR)

During the 1970's, TLNWR staff farmed approximately 2,000 acres of small grains. This program was intended to provide food for waterfowl and provide waterfowl depredation relief to farmers on private lands. This program was discontinued in the 1980s in favor of a program using cooperating farmers. Under this program, the farmer provided all costs of establishing a crop, harvested two-thirds of the crop, and left one-third standing for waterfowl consumption. This was deemed an acceptable change because populations of waterfowl in the Pacific Flyway (particularly geese) in the 1980s were lower than previous decades, and much of the standing grain was not used. The cooperative farming program was reduced in the 1990s. As a result of changes to the farming program, the acres in unharvested grains declined from about 2,000 acres in the 1970's to 250 acres by 2005.

Dabbling duck and goose populations at TLNWR have substantially declined since the 1970s (see Figures 2-6 and 2-7), as has the acreage of standing grains. We developed this management alternative to determine if increasing standing grain acreage to 1970s levels (2,000 acres) could support desired dabbling duck and goose population objectives.

Outcome.-- Increasing unharvested grains from 250 to 2,000 acres would allow TLNWR to meets the foraging needs of dabbling ducks (Figure 4-27) and geese (Figure 4-28). From a purely energetic standpoint, the decline in dabbling duck and goose populations since the 1970's on TLNWR may in fact be related to this reduction in unharvested grains.

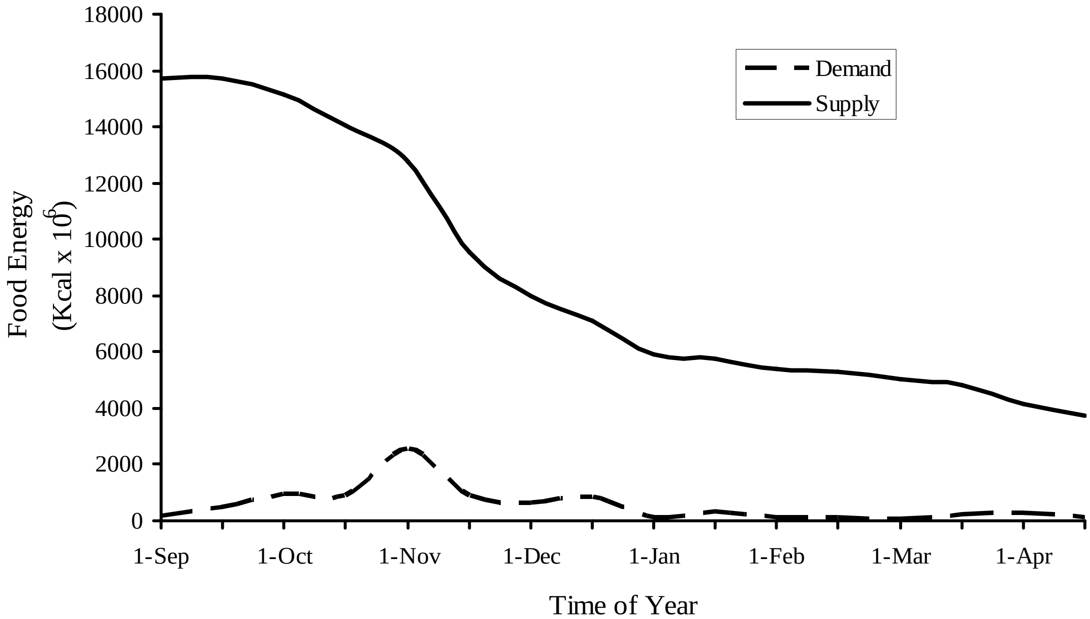


Figure 4-27. Population energy demand vs. food energy supplies for dabbling ducks at TLNWR if standing grain acreage is returned to 1970's level (Model 5).

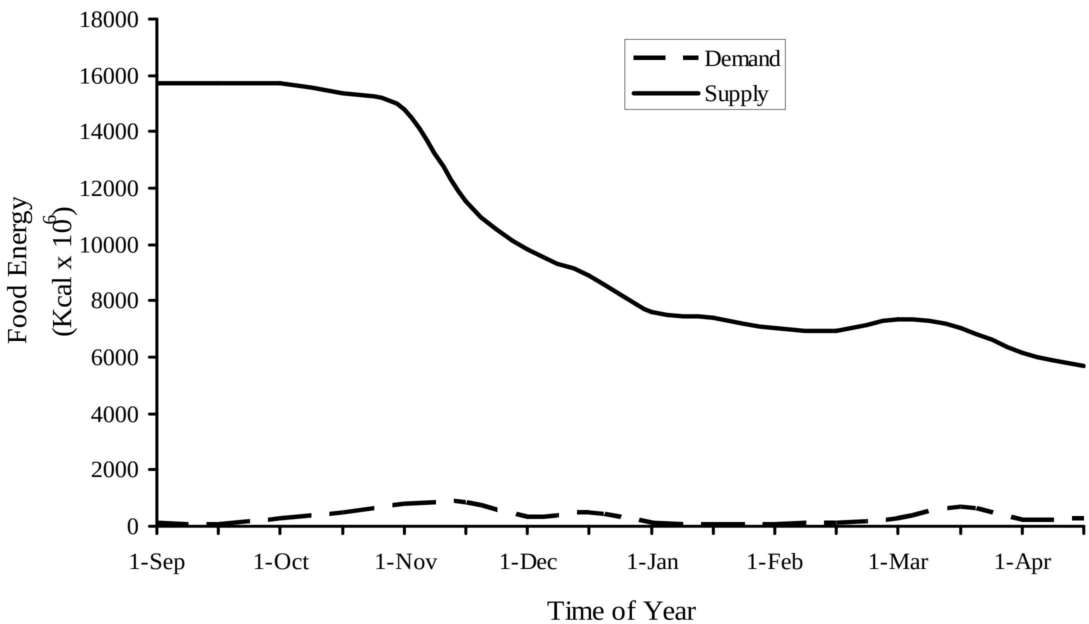


Figure 4-28. Population energy demand vs. food energy supplies for geese at TLNWR if standing grain acreage is returned to 1970's level (Model 5).

Model 6: Seasonal Wetland Emphasis (TLNWR)

The Central Valley of California has also used TRUMET to determine population objectives and habitat needs for wintering waterfowl in this critical area of the Pacific Flyway. Waterfowl managers and biologists have determined, as a goal for the Central Valley, that sufficient wetland habitats are available to meet 50% of waterfowl energy needs. Presently, waterfowl in this area make extensive use of agricultural lands, principally rice; however, it is possible that changes in agriculture policy or farm economics may reduce the acreage of this important food resource. Increasing seasonal wetlands may be desirable because wetland foods are generally more nutritionally diverse and they provide for more species of waterfowl and wetland dependent birds.

Management alternative two asked how many acres of seasonal wetland habitats would be required to meet 50% of dabbling duck energy needs at TLNWR given stated population objectives in Chapter 2. We required that 70% of this seasonal wetland acreage be allocated to early succession habitat and that dabblers meet 75% of their energy needs on refuge. To answer this question, we incrementally increased the acreage of seasonal wetlands and reduced the acres dedicated to harvested grains.

Fifty percent of dabbler energy needs were met when seasonal wetlands totaled 8,000 acres (an increase of 7,350 acres). Converting this much land to seasonal wetlands altered the ability of TLNWR to meet the energy demands for other guilds, especially geese. The refuge could meet all population objectives if the 8,471 acres of harvested grains now existing at TLNWR were converted to 7,845 acres of seasonal wetlands and 626 acres of standing grains (Table 4-7).

Model 7: Minimum Agricultural Footprint (TLNWR)

In this scenario, we altered the habitat composition on TLNWR to estimate the balance of habitat types that could meet the foraging habitat needs for each guild with the minimum amount of agricultural. There are currently 14,828 acres devoted to agriculture on TLNWR. Refuge foraging habitat objectives could still be met for all waterfowl guilds if agricultural acreage is reduced to 6,605 acres and the remaining 8,223 acres is converted to seasonal wetlands. Furthermore, the 6,605 acres of agricultural habitat would be partitioned to 1,200 acres of standing grains and 5,405 acres of alfalfa pasture (Table 4-7).

Model 8: Minimum Standing Grain (TLNWR)

The last management alternative estimated the minimum amount of standing grain that could be grown at TLNWR while still meeting refuge foraging habitat objectives for each guild. When modeling this alternative, we held the acreage dedicated to permanent wetlands, potatoes, and alfalfa constant at current conditions. Thus, increases in unharvested grain came at the expense of seasonal wetlands and harvested grain fields.

Energy needs for all waterfowl guilds could be met if standing grains are increased to 1,504 acres. This could be achieved by converting all 155 acres of seasonal wetlands at TLNWR to standing grains and converting 1,100 acres of harvested grains to standing grains (Table 4-7).

Table 4-6. Summary of TRUEMET model runs for Lower Klamath National Wildlife Refuge.

	Model			
	Model #1 Current Conditions	**Model #2 Population objectives**	**Model #3 Using agriculture to meet goose needs**	**Model #4 "Big Pond" Scenario**
Goal	Determine if current management is meeting needs of current waterfowl populations.	Determine if current habitat conditions can meet population objectives established in Chapter 2.	Determine acreage of standing grain and pasture needed to achieve goose objectives.	Evaluate whether dedicating 13,000 acres of refuge to winter/spring flooding will meet waterfowl objectives.
Reliance on Refuge foods	100% for all guilds	75% for geese and dabblers 100% for remaining guilds	75% for geese and dabblers 100% for remaining guilds	75% for geese and dabblers 100% for remaining guilds
Waterfowl populations	Mean 1990s abundance for all guilds.	75^{th} percentile of 1970s duck and 1990s goose populations	75^{th} percentile of 1970s duck and 1990s goose populations	75^{th} percentile of 1970s duck and 1990s goose populations
Small grains	6,534 (harvested) 1,057 (unharvested)	6,534 (harvested) 1,057 (unharvested)	4,034 (harvested) 1,557 (unharvested)	6,534 (harvested) 1,057 (unharvested)
Pasture/Hay	2,018	2,018	4,018	2,018
Seasonal Wetland	4,834 (early) 11,280 (late)	4,834 (early) 11,280 (late)	4,834 (early) 11,280 (late)	3,216 (early) 9,648 (late)
gent wetland	1,939	1,939	1,939	1,300
Submergent wetland	7,355	7,355	7,355	5,200
Summarized outcome	Goose foods insufficient winter and spring	Goose foods insufficient winter and spring.	Needs of all waterfowl guilds are met.	dabblers good, increases coot deficit divers and swans sufficient

Table 4-7. Summary of TRUEMET model runs for Tule Lake National Wildlife Refuge

	Model #1 Current Conditions	Model #2 Population objectives	Model #5 Increased Grain	Model #6 Seasonal Wetlands	Model #7 Minimum Ag Footprint	Model #8 Standing Grain
Goal	Determine if current management is meeting needs of current waterfowl populations.	Determine if current habitat conditions can meet population objectives established in Chapter 2.	Verify that standing grain acreage in the 1970's supported observed waterfowl numbers.	Determine seasonal wetland acres needed to supply 50% of dabbling duck needs.	Minimize acreage of agricultural crops while meeting population objectives	Minimum standing grain required while minimally effecting current farm program.
Reliance on Refuge Foods	100% for all guilds	75% for geese 75% for dabblers 100% for others	100% of needs for all guilds met on refuge	75% geese/dabblers 100% for others	75% for geese and dabblers 100% for remaining guilds	75% for geese and dabblers 100% for remaining guilds
Waterfowl Populations	Mean 1990's all guilds.	75^{th} percentile of 1970s duck 1990s goose populations	Mean populations from the 1970s	75^{th} percentile of 1970s duck and 1990s goose populations	75^{th} percentile of 1970s duck and 1990s goose populations	75^{th} percentile of 1970s duck and 1990s goose populations
Potato acreage	2,703	2,703	2,703	2,703	0	2,703
Small grains	8,471 (harvested) 249 (unharvested)	8,471 (harvested) 249 (unharvested)	6,720 (harvested) 2,000 (unharvested)	875 (unharvested)	0 (harvested) 1,200 (unharvested)	7,370 (harvested) 1,504 (unharvested)
Alfalfa/Hay	3,405	3,405	3,405	3,405	5,405	3,405
Seasonal Wetland	0 (early) 155 (late)	0 (early) 155 (late)	0 (early) 155 (late)	5,600 (early) 2,400 (late)	5,865 (early) 2,513 (late)	0 (early) 0 (late)
Emergent/ Submergent Wetland	3,030/11,539	3,030/11,539	3,030/11,539	3,030/11,539	3,030/11,539	3,030/11,539
Summarized Outcome	Goose and dabbler food resources inadequate	Goose and dabbler foods insufficient	Needs of dabbling ducks and geese met.	8,000 acres of seasonal wetlands take from harvested grain acreage	8,223 acres ag lands converted to seasonal wetlands. Remaining acres in alfalfa/standing grain.	1,504 acres standing grain needed to meet dabbler/goose needs.

Discussion

TRUEMET

The results produced by TRUEMET are a function of model structure and parameter inputs; thus, there are two types of error inherent in any modeling exercise, conceptual (theoretical assumptions used to build the model) and empirical (the availability, precision and accuracy of data used for model inputs). Model structure was determined by the set of rules that dictated how birds foraged. We assumed: 1) birds were ideal free foragers (Fretwell 1972) and were not prevented from accessing food resources due to interference competition; 2) birds switched to alternate foods when preferred foods were depleted below some foraging threshold; 3) the functional relationships that determined population energy demand and population food energy supplies were linear; and 4) that there was no cost associated with traveling between foraging patches. In some cases, empirical work has shown these assumptions to be false (e.g., Nolet et al. 2006); however, in other cases our assumptions are valid (Arzel et al. 2007, Goss-Custard et al. 2003). Additional studies of waterfowl foraging ecology would either improve model structure of confirm the validity of our daily ration approach. However, to date there is no model that can replicate such detail for the range of species that occur on TLNWR and LKNWR.

We had empirical estimates for all key parameters except the extent that waterfowl relied on refuge energy sources to meet their daily energy needs. Our evaluation of carrying-capacity was strongly dependent on energy demand; thus, our assumption that guilds derived 75-100% of their daily energy needs from refuge foods heavily influenced model results. The largest uncertainty was for dabbling ducks and geese. When modeling large landscapes like California's Central Valley, we can reasonably assume those waterfowl groups derive 100% of their needs from the landscape being modeled. At smaller spatial scales like TLNWR and LKNWR, daily observations of birds flying off both refuges indicate this assumption is not true. Estimates of this parameter for geese and dabblers would help improve our understanding of past and current habitat conditions, but ultimately may not be necessary for conservation planning by refuge staff, who will likely define this parameter based on refuge goals and objectives.

Modeling results can always be improved by better estimates of model inputs. However, our estimates of food abundance were reasonably precise (CV's < 20%) and our calculation of metabolizable energy reflected a composite value derived from TME estimates based on controlled feeding experiments and field sampling that estimated each plant species contribution to seed biomass. Our approach was more detailed than previous efforts in North America that have applied the mean TME for wetland plant seeds (e.g., CVJV 2006).

While we feel model inputs are reasonable, it is prudent to consider the consequences of any parameter estimate being wrong. Because all variables in the model varied with each other in a linear fashion, the impact of an error is directly proportional to the size of the error. For example, if 1,000 diving ducks each required 100 kcal of energy per day to meet their needs this equates to a population energy demand of 100,000 kcal/d. We required that diving ducks meet all their daily energy demands from refuge foods. If only 50% of this demand is met from refuge foods, then refuge energy demand is cut by half. Similarly, if true mean food densities are 25% lower than our estimates, our estimate of total energy is 25% too high. Our assumptions about the habitats used by each foraging guild will also influence our evaluation of refuge carrying capacity. Assumptions that are too restrictive and overlook habitats that provide important food resources to certain guilds will lead to underestimations of carrying capacity, while granting foraging guilds access to habitats not used will produce the opposite result. In general, we believe that the foraging guild – habitat associations described in Table 4-4 do reflect the foods eaten by each guild to meet their energy needs.

Current Conditions

Despite these caveats, results for our "current conditions" model (Model 1) are consistent with waterfowl population differences on both refuges during the 1970s versus 1990s. The decline in dabbling duck abundance at TLNWR from the 1970s to the 1990s is consistent with a drop in food abundance over that period (i.e., the loss of standing grain). In contrast, dabbling duck counts at LKNWR were stable to increasing during this period (Figure 2-6) consistent with our modeling that showed habitats can meet current dabbler needs for most of the season (Figure 4-3).

Habitat conditions for divers and swans at LKNWR are sufficient to meet 100% of bird energy needs in all time periods, with significant food resources remaining even after birds depart in spring (Figure 4-1). This surplus in food resources is consistent with the substantial increase in diving duck (Figure 2-8a) and swan use (Figure 2-9a) of LKNWR from the 1970's to the 1990's. In contrast, habitat conditions for divers and swans at TLNWR were only able to meet 100% of bird needs until early spring by which time food resources were completely depleted (Figure 4-6). However diving duck use of TLNWR has increased since the 1970's (Figure 2-8b), while swan numbers have remained similar over this time period (Figure 2-9b). Our estimate of energy available to swans and diving ducks was conservative because we did not allow swans to forage in flooded agricultural fields or allow diving ducks to feed on benthic invertebrates. Both foraging behaviors are known to occur. If swans do meet a significant amount of their energy needs from agricultural habitats it would reduce the depletion of root and tuber food resources used by diving ducks and perhaps explain how diving duck populations have increased despite the apparent exhaustion of food resources by spring.

The explanation for low fall goose numbers at TLNWR in the 1990s seems to lie outside refuge habitat conditions. Most notably, the large number of Cackling Geese that historically used the refuge in fall during migration, now winter farther north. However, it does appear that refuge management decisions driven by lower fall goose numbers (reduced the acreage of standing grain) may have influenced dabbling duck use of TLNWR. At LKNWR, habitats meet goose needs farther into winter, but are exhausted by late winter. This in conjunction with increasing goose population size in spring explains the spring energy deficit on the refuge. Given refuge foods are insufficient to support the increasing spring goose population; we would predict that geese are increasingly relying on private lands for food, a prediction supported by recent field observations (D. Mauser).

We did not model carrying capacity for either Ruddy Ducks or scaup as we lacked information on the abundance of benthic invertebrates at both Tule Lake and Lower Klamath. Both species rely heavily on benthic invertebrates to meet their nutritional needs. Additional field work to sample benthic invertebrate populations is needed to close these gaps.

Ability of Refuges to meet Population Objectives

Lower Klamath and Tule Lake National Wildlife Refuges provide a distinct contrast in their ability to meet population objectives for dabbling ducks. Food supplies for dabbling ducks at LKNWR are well above population energy demand from fall through spring (Figure 4-12). In contrast, food supplies at TLNWR are exhausted by early November (Figure 4-18). Dabbler use of TLNWR traditionally peaked in early November (Figure 2-6b), and the depletion of food resources by this date indicates the refuge is no longer capable of supporting dabbling duck numbers typical of the 1970s.

The difference in the ability of the two refuges to meet population objectives is reflected in the habitats they provide. Dabbling ducks at LKNWR have access to over 15,000 acres of seasonal wetlands and over 1,000 acres of standing grains (Table 4-1). Both of these habitats provide substantial food resources (Table 4-2). Additionally, these seasonal wetlands provide a greater diversity of foods and can therefore meet the dietary needs for a broader range of waterfowl and a greater number of other wetland-dependent species. In contrast, TLNWR provides less than 200 acres of seasonal wetland and less than 300 acres of standing grains (Table 4-1). Outside of permanent wetlands, much of the land base of TLNWR is devoted to harvested grains that provide relatively little food for a relatively small number of duck and waterbird species (Table 4-2).

Food resources at LKNWR were sufficient to meet goose population objectives through mid-March (Figure 4-15), while food resources at TLNWR were exhausted by mid-December (Figure 4-19). Because of their high energy-density values, acreage planted to standing grain and potatoes had the greatest impact on fall and winter geese. We assumed that green browse (alfalfa, pasture) became available as a food for geese by March 1. This provided a significant increase in energy supply at TLNWR with food resources nearly adequate to meet goose population objectives from March 1 onward (Figure 4-19). Although green browse also increased spring food resources for geese at LKNWR, food supplies remained well below population demand because insufficient acres of green browse are planted at LKNWR (Table 4-1).

Finally, both LKNWR and TLNWR can meet population objectives for diving ducks and swans from existing refuge habitats (Figures 4-11 and 4-16). Carrying capacity was higher at LKNWR despite the fact that TLNWR has 4,000 more acres of permanent wetlands than LKNWR (Table 4-1). The quality of permanent habitats at LKNWR was much higher with root and tuber biomass nearly five times greater than at TLNWR (Table 4-2) and shallower water depths that made benthic foods generally more available to swans. This result indicates that rehabilitation of permanent wetland habitats at TLNWR (i.e., drawing down sump 1a) has considerable potential to change carrying capacity for diving ducks in the Klamath Basin.

Management Alternatives

We used our model to evaluate several possible management alternatives to address food deficiencies identified in Model 2. Our suite of alternative models indicated there are likely many possible alternate habitat arrangements that can meet waterfowl food needs. Our suite of models was not exhaustive; but was developed to illustrate how a wide range of different management approaches might alleviate identified foraging deficiencies on TLNWR and LKNWR. In addition, we modeled one potential approach (Big Pond Scenario) that could reduce LKNWR's reliance on summer and early fall water deliveries. We organize the remaining discussion around two central topics, agriculture and water.

Agriculture.-- The most efficient way to increase energy supply on both refuges (i.e., most kcal/acre) to meet the energy needs of dabbling ducks and geese is to increase the amount of standing (unharvested) grain. Converting lands from harvested to unharvested grain fields provides refuge staff with flexibility when thinking about alternate habitat scenarios because the very high energy yields of unharvested crops allows a large number of previously harvested acres to be potentially converted to other more diverse or food rich habitats. For example, the refuge could meet its dabbling duck and goose needs at LKNWR by converting 2,500 acres of harvested grain to 500 acres of standing grain, leaving the remaining 2,000 for other uses (Figure 4-22).

However, agricultural grains lack essential amino acids provided by natural foods and relatively few waterfowl species consume grain, so refuge staff may consider providing waterfowl with a better balance of natural and agricultural foods, particularly on TLNWR. Converting 7,845 acres of the 8,471 acres of harvested grain fields now present at TLNWR to seasonal wetlands would allow the refuge to provide 50% of dabbler energy needs from natural food resources (Model 6). However, it would also require that all remaining acres of harvested grain fields be converted to standing grain. In essence, this management alternative would eliminate the harvesting of grain crops at TLNWR. Other alternatives could include converting some permanent wetlands to seasonal wetlands. This option is feasible if the quality of permanent wetlands on TLNWR can be improved to meet the needs of diving ducks, swans, and coots.

The amount of food provided by harvested grains at both Tule Lake and Lower Klamath is low (Table 4-1, Table 4-2). Estimates of waste grain abundance in harvested fields on both refuges are from the 1980s and are low compared to work elsewhere (Miller et al. 1989). However, recent work in the Midwest indicates that waste rice (Stafford et al. 2006) and corn (Krapu et al. 2004) available to waterfowl in agricultural fields has significantly declined since 1980. Given the prominence of the agriculture program on both LKNWR and TLNWR, and the sensitivity of model output to estimates of food biomass, the refuge complex has initiated a study to resample waste grain and green browse abundance that is scheduled to begin in spring 2008.

Agriculture is most prominent at TLNWR; occupying 50% of the refuge's approximately 30,000 acres (most of the remaining area is permanent wetlands). In theory, most waterfowl foraging guilds could be sustained solely using wetland habitats. Consequently, one of our alternate models (Model 7) asked the question "what is the minimum amount of TLNWR land that must be devoted to agriculture to meet population objectives for all foraging guilds (with the exception of geese)?" Results indicated that agricultural lands could be reduced from 15,000 acres to 6,600 with agricultural lands partitioned as 1,200 acres of unharvested grains and 5,400 acres of green browse. The balance of lands formally dedicated to agriculture (8,400 acres) would need to be converted to seasonal wetlands. In general, an increase in acres dedicated to green browse is needed to meet the energy needs of geese in spring.

Water availability.-- Potential water shortages in the Klamath Basin now pose the greatest threat to traditional management practices at LKNWR. Shortages are most likely in summer and early fall and can reduce the summer water deliveries needed to maintain permanent wetland habitats, and delay the flooding of seasonal wetlands that typically begins in September. Variation in food production among habitat types provides one option for dealing with potential water shortages.

Sampling wetland habitats revealed considerable variation in seed biomass between our early and late successional seasonal wetlands and in tuber production between permanent wetlands on TLNWR and LKNWR (Chapter 3). Early successional seasonal wetlands are relatively more important to foraging waterfowl than late successional habitats because they produce more, higher quality seed. Similarly, permanent wetlands at LKNWR produced greater tuber biomass. Both results indicate that more intensive management can improve food production in natural wetlands without increasing the acreage dedicated to those habitats. At TLNWR, Sump 1A has been permanently flooded for decades. Wetland productivity declines under years of static flooding regimes. Submerged aquatic vegetation production would be improved by drawing down the sump, which would dry and consolidate the soils. A drawdown was performed on Sump 1B in 2002 and this did result in improved stands of sago pond weed following flooding in 2003 (D. Mauser pers. obs.). In addition, in the spring when soils were exposed, moist-soil plants produced large quantities of high quality seeds in 2002 (Chapter 3).

Increasing management emphasis on early successional wetlands is more intensive and may require additional staff, equipment, and fuel. Our models did not include cost functions that could be used to identify management scenarios that balance costs with biological function (Rashford et al. 2008). However, proposed expansion of the refuge's Walking Wetlands Program may create the opportunity for expansion of seasonal wetland habitat without significant changes in refuge operating costs.

Traditionally, most seasonal wetlands are flooded starting in early fall. This corresponds to a period when water supplies in the Klamath Basin are often limited. Incurring additional costs to maintain these wetlands in an early succession stage may still be attractive if it reduces the acres of seasonal wetlands needed to meet bird energy needs, and thus the amount of water needed to achieve objectives. Alternatively, Model 2 indicated that food availability far surpasses bird energy needs early in the season. This suggests it may be possible to delay flooding of some seasonal wetlands until winter without significantly reducing the refuges ability (mostly at LKNWR) to support fall migrating waterfowl. Giving priority to flooding early successional wetlands in early fall would provide the most food for a given amount of water.

Permanent wetlands require water inflows during most months of the year. This habitat type is important to all guilds of waterfowl, but most important to swans, diving ducks, and coots that use this habitat extensively for foraging. Permanent wetlands are also critical to breeding wetland birds. Our sampling of submerged aquatic vegetation on TLNWR suggests it may be possible to reduce the total acres of permanent wetlands needed, thereby saving water, by managing for high quality permanent wetlands like those occurring at LKNWR. However, given the needs of other wetland birds, particularly species that breed in the Klamath Basin, this may not be desirable.

Alternately, the refuge is exploring options to capture water in winter and early spring, when water supplies in the Klamath Project area are generally not limited, by increasing the total acres dedicated to permanent wetlands at LKNWR. This thinking was the basis for Model 4, "The Big Pond Scenario (BPS)". The BPS would convert 25% of all seasonal wetlands to permanent wetlands, resulting in a total of 13,000 acres when the BP was full. Even if this wetland received no summer water deliveries, approximately half of the 13,000 acres is expected to contain water through summer and fall. The creation of a larger lake may increase the likelihood of providing reliable breeding habitat for colonial waterbirds like American White Pelican, Double-crested Cormorants and Caspian Terns.

Our analysis indicates the BPS may represent an alternative management strategy for meeting waterfowl population objectives if long-term solutions are not found to alleviate summer and early fall water shortages. Converting seasonal wetlands to permanent wetlands will reduce foods for dabbling ducks; however, food resources at LKNWR still appear sufficient to meet population objectives for dabbling ducks because of an existing surplus in dabbler foods. In contrast, the increase in permanent wetlands achieved under the Big Pond alternative actually lowered foods available to diving ducks and swans (but foods were still sufficient to meet the needs of these divers and swans). This resulted from much of the Big Pond's substrate being exposed on an annual basis through evaporation, and a subsequent reduction in the submerged aquatic plant communities used by divers and swans. This may be mitigated if some water is available during the irrigation season to offset evapotranspiration. Our analysis of the BPS scenario did not consider water depth. Creation of a much larger lake will create areas of deeper water than currently exist on LKNWR. The growth of submerged aquatic plants generally declines when water depths exceed 1 m and diving ducks and swans may have a more difficult time accessing plant tubers in deeper water.

Our evaluation of current conditions and management alternatives provides insight into how wetland and agricultural habitats can be used to meet waterfowl needs. We recognize that our alternatives are not exhaustive and that there are physical, biological, and legal constraints associated with potential implementation. For example, current water delivery priorities for both refuges are low relative to other water uses in the Klamath Project. In addition, legislation, particularly Public Law 88-567 (Kuchel Act), provides guidance to the Service that directly relates to habitat management on both refuges. We have also not considered the potential effects that management alternatives may have on other non-waterfowl wildlife species. However, we hope this report provides guidance that will help shape the discussion and provide a context for objectively considering how possible land use changes can impact wintering and migrating waterfowl. Our results indicate a variety of habitat scenarios can meet the energy needs of migrating and wintering waterfowl, thus providing flexibility to refuge managers as they consider the broader suite of wildlife species that depend on both refuges to meet their life-cycle needs.

V. Literature Cited

Alisauskas, R. T. and T. W. Arnold. 1994. American Coot. Pages 127-143 *in* T. C. Tacha and C. E. Braun, eds. Migratory Shore and Upland Game Bird Management in North America. Allen Press, Lawrence, KS.

Association of Official Analytical Chemists. 2000. Official methods of Analysis. Seventeenth edition, Association of Analytical Chemists, Washington D.C.

Arzel, C., M. Guillemain, D. B. Gurdd, J. Elmberg, H. Fritz, A. Arnaud, C. Pinf, F. Bosca. 2007. Experimental functional response and inter-individual variation in foraging rate of teal (*Anas crecca*). Behavioural Processes 75:66–71.

Aschoff, J. and H. Pohl. 1970. The resting metabolism of birds as a function of daylight and stature. Journal für Ornithologie 111:38-47.

Baldassarre, G. A. and E. G. Bolen. 1984. Field-feeding ecology of waterfowl wintering on the southern high plains of Texas. Journal Wildlife Management 48:63-71.

Ballard, B. M., J. E. Thompson, M. J. Petrie, J. M. Checkett, and D. G. Hewitt. 2004. Diet and nutrition of northern pintails wintering along the southern coast of Texas. Journal of Wildlife Management 68:371-382.

Bellrose, F. C. Ducks, Geese, and Swans of North America. Stackpole, Harrisburg, PA.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons, New York, NY.

Central Valley Habitat Joint Venture. 2006. Central Valley Habitat Joint Venture Implementation Plan. Sacramento CA.

Checkett, J. M., R. D. Drobney, M. J. Petrie, and D. A. Graber. 2002. True Metabolizable energy of moist-soil seeds. Wildlife Society Bulletin 30:1113-1119.

Delnicki, D. and K. J. Reinecke. 1986. Mid-winter food use and body weights of mallards and wood ducks in Mississippi. Journal of Wildlife Management 50:43-51.

Dugger B. D., M. L. Cline, R. S. Finger, and M. J. Petrie. 2007. True metabolizable energy of four common moist-soil seed species in the western U.S. Journal of Wildlife Management 71:1964-1967.

Ely, C. R. and D. G. Raveling. 1989. Body-composition and weight dynamics of wintering Greater White-fronted Geese. Journal of Wildlife Management 53:80-87.

Esslinger, C. G. and B. C. Wilson. 2001. North American Waterfowl Management Plan, Gulf Coat Joint Venture: Chenier Plain Initiative. North American Waterfowl Management Plan, Albuquerque, NM.

Fredrickson, L. H. and T. S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. Resource Publication 148, United States Department of Interior, Fish and Wildlife Service, Washington, DC.

Fretwell, S. 1972. Populations in a seasonal environment. Princeton University Press.

Fritz H., M. Guillemain, and D. Durant. 2002. The cost of vigilance for intake rate in the mallard (*Anas platyrhynchos*): an approach through foraging experiments. Ethology Ecology & Evolution 14:91-97.

Gilmer, D.S., Yee, J.L., Mauser, D.M., and Hainline, J.L. 2004. Waterfowl migration on Klamath Basin National Wildlife Refuges 1953–2001. U.S. Geol. Surv. Biol. Sci. Rep. No. USGS/BRD/BSR-2003-0004.

Goss-Custard, J. D., R. A. Stillman, R. W. G. Caldow, A. D. West, and M. Guillemain. 2003. Carrying capacity in overwintering birds: when are spatial models needed? Journal of Applied Ecology 40:176-187.

Goss-Custard, J. D., R. A. Stillman, A. D. West, R. W. G. Caldow, and S. McGrorty. 2002. Carrying capacity in overwintering migratory birds. Biological Conservation 105:27-41.

Goss-Custard, J. D., N. H. K. Burton, N. A. Clark, P. N. Ferns, S. McGrorty, C. J. Reading, M. M. Rehfisch, R. A. Stillman, I. Townsend, A. D. West, and D. H. Worrall. Test of a behavior-based individual-based model: response of shorebird mortality to habitat loss. Ecological Applications 16:2215-2222.

Greer, A., B. D. Dugger, D. Graber, and M. J. Petrie. 2007. Influence of spring flooding on food availability to spring migrating waterfowl. Journal of Wildlife Management 71:1561-1566.

Guillemain, M., H. Fritz, and S. Blais. 2000*a*. Foraging methods can affect patch choice: an experimental study in Mallard (*Anas platyrhynchos*). Behavioral Processes

50:123-129.

Guillemain, M., H. Fritz, and N. Guillon. 2000*b*. Foraging behavior and habitat choice of wintering northern shoveler in a major wintering quarter in France. Waterbirds 23:353-363.

Hepp, G. R., R. J. Blohm, R. E. Reynolds, J. E. Hines, and J. D. Nichols. 1986. Physiological condition of autumn-banded mallards and its relationship to hunting vulnerability. Journal of Wildlife Management 50:177-183.

Hoffman, R. D. and T. A. Bookhout. 1985. Metabolizable energy of seeds consumed by ducks in Lake Erie marshes. Transactions of the North American Wildlife and Natural Resources Conference 50:557-565.

Kaminski, R. M. and E. A. Gluesing. 1987. Density-related and habitat related recruitment in Mallards. Journal of Wildlife Management 51:141-148.

Kaminski, R. M., J. B. Davis, H. W. Essig, P. D. Gerard, and K. J. Reinecke. 2003. True metabolizable energy of Wood Ducks from acorns compared to other waterfowl foods. Journal of Wildlife Management 67:542-550.

Kantrud, H. A. 1990. Sago pondweed (*Potamogeton pectinatus* L.): A literature review. U.S. Fish and Wildlife Service, Fish and Wildlife Resource Publication 176.

Kapantais, K., N. D. Athearn, and J. Y. Takekawa. 2003. Waterfowl foods in agricultural fields of the Klamath Basin. Unpublished Report. U.S. Geological Survey, Vallejo, CA.

Klaassen, R. H. G., B. A. Nolet, and C. H. A. Van Leeuwen. 2007. Prior knowledge about spatial pattern affects patch assessment rather than movement between patches in tactile-feeding mallard. Journal Animal Ecology 76:20-29.

Krapu, G. L. 1981. The role of nutrient reserves in Mallard reproduction. Auk 98:29-38.

Krapu, G. L., D. A. Brandt, and R. R. Cox, Jr. 2004. Less waste corn, more land in soybeans, and the switch to genetically modified crops: trends with important implications for wildlife management. Wildlife Society Bulletin 32:127-136.

Kross, J. 2006. Conservation of Waste Rice and Estimates of moist-soil seed abundance for wintering waterfowl in the Mississippi Alluvial Delta. M.S. Thesis, Mississippi State University, Starksville.

Laubhan, M. K. and L. H. Fredrickson 1992. Estimating seed production of common plants in seasonally flooded wetlands. Journal of Wildlife Management 56:329-337.

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger. 1996. SAS System for Mixed Models. SAS Institute Inc., Cary, NC, USA.

Loesch, C. R., K. J. Reinecke, and C. K. Baxter. 1994. Lower Mississippi Valley Joint Venture evaluation plan. North American Waterfowl Management Plan, Vicksburg, Mississippi, USA.

Lovvorn, J. R. and J. R. Baldwin. 1986. Intertidal and farmland habitats of ducks in the Puget Sound Region: a landscape perspective. Biological Conservation 77:97-114.

Miller, M. R. and J. M. Eadie. 2006. The allometric relationship between resting metabolic rate and body mass in wild waterfowl (Anatidae) and an application to estimation of winter habitat requirements. Condor 108:166-177.

Miller, M. R. and W. E. Newton. 1999. Population energetics of northern pintails wintering in the Sacramento Valley, California. Journal of Wildlife Management 63:1222-1238.

Miller, M. R. and K. J. Reinecke. 1984. Proper expression of metabolizable energy in avian energetics. Condor 86:396-400.

National Ecological Assessment Team. 2006. Strategic Habitat Conservation. U. S. Geological Survey. http://www.fws.gov/science/doc/SHC_FinalRpt.pdf

Naylor, L. W. 2002. Evaluating moist-soil seed production and management in Central Valley wetlands to determine habitat needs for waterfowl. Thesis. University of California, Davis, USA.

Nolet, B. A., O. Langevoord, R. M. Bevan, K. R. Engelaar, M. Klaassen, R. J. W. Mulder, and S. VanDijk. 2001. Spatial variation in tuber depletion by swans explained by differences in net intake rates. Ecology 82:1655-1667.

Nolet, B. A., A. Gyimesi, and R. H. G. Klasssen. 2006. Prediction of bird-day carrying capacity on a staging site: a test of depletion models. Journal of Animal Ecology 75:1285-1292.

North American Waterfowl Management Plan, Plan Committee. 1986. North American Waterfowl Management Plan: a strategy for cooperation. Canadian Wildlife Service, U. S. fish and Wildlife Service.

North American Waterfowl Management Plan, Plan Committee. 2004. North American Waterfowl Management Plan 2004. Strategic Guidance: Strengthening the Biological Foundation. Canadian Wildlife Service, U.S. Fish and Wildlife Service, Secretaria de Medio Ambiente y Recursos Naturales.

Pacific Flyway Council. 1999. Pacific Flyway management plan for the cackling Canada goose. Cackling Canada Goose Subcommittee, Pacific Flyway Study Comm. [c/o USFWS], Portland, OR.

Parsons, C. M., L. M. Potter, and B. A. Bliss. 1982. True metabolizable energy corrected for nitrogen equilibrium. Poultry Science 61:2241-2246.

Pederson, G. B. and R. L. Pederson. 1983. Feeding ecology of pintails and mallards on Lower Klamath marshes. U.S. Fish and Wildlife Service, Report # 14-16-0001-79106. Humboldt State University, Arcata, California.

Percival S. M., W. J. Sutherland, and P. R. Evans. 1996. A spatial depletion model of the responses of grazing wildfowl to the availability of intertidal vegetation. Journal of Applied Ecology 33:979-992.

Petrie, M. J., R. D. Drobney, and D. A. Graber. 1997. Evaluation of true metabolizable energy for waterfowl. Journal of Wildlife Management 61:420-425.

Petrie, M. J., R. D. Drobney, and D. A. Graber. 1998. True metabolizable energy estimates of Canada goose foods. Journal of Wildlife Management 62:1147-1152.

Pollock, K. H. and W. L. Kendall. 1987. Visibility bias in aerial surveys: A review of estimation procedures. Journal of Wildlife Management 51:502-510.

Rashford, B. S, B. D. Dugger, and R. M. Adams. 2008. Application of a bioeconomic optimization model to improve waterfowl management. Journal of Wildlife Management *in press*.

Raveling, D.G. 1979. The annual energy cycle of the cackling Canada goose. Pages 81-93 *in* R.L. Jarvis and J.C. Bartonek, editors. Management and biology of Pacific flyway geese: a symposium. OSU Book Stores, Inc. Corvallis, OR.

Raveling, D. G. and M. E. Heitmeyer. 1989. Relationship of population size and recruitment of pintails to habitat conditions and harvest. Journal of Wildlife Management 53:1088-1103.

Reinecke, K. J., R. M. Kaminski, D. J. Moorhead, J. D. Hodges, and J. R. Nassar. 1989. Mississippi Alluvial Valley. Pages 203-247 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock, Texas, USA.

Reinecke, K. J. and K. M. Hartke. 2005. Estimating moist-soil seeds available to waterfowl with double sampling for stratification. Journal of Wildlife Management 69:794-799.

Rutka, D. M. 2004. Waste rice depletion by waterfowl wintering in the Mississippi Alluvial Valley. Thesis. Southern Illinois University, Carbondale, USA.

SAS Institute. 1999. SAS/STAT user's guide. Version 8. SAS Institute, Cary, North Carolina, USA.

Sherfy, M. H. 1999. Nutritional value and management of waterfowl and shorebird foods in the Atlantic Coastal moist-soil impoundments. Dissertation, Virginia Polytechnic Institute and State University, Blacksburg, USA.

Sibbald, I. R. 1976. A bioassay for true metabolizable energy in feeding stuffs. Poultry Science 55:303-308.

Sibbald, I. R. and P. M. Morse. 1982. The effects of nitrogen correction and of feed intake on true metabolizable energy values. Poultry Science 62:138-142.

Sutherland, W.J. 1996. From individual behaviour to population ecology. Oxford University. New York, USA.

Stafford, J. D., R. M. Kaminski, K. J. Reinecke, and S. W. Manley. 2006. Waste rice for waterfowl in the Mississippi Alluvial Valley. Journal of Wildlife Management 70:61-69.

Stillman, R. A., A. D. West, J. D. Goss-Custard, S. McGrorty, N. J. Frost, D. J. Morrisey, A. J. Kenny, A. L. Drewitt. Predicting site quality for shorebird communities: a case study on the Humber estuary, UK.   Marine Ecology Progress Series 305: 203–217.

Sutherland, W. J. and G. A. Allport. 1994. A spatial depletion model of the interaction between bean geese and wigeon with the consequences for habitat management. Journal of Animal Ecology 63:51-59.

Taylor, J.P. and L.M. Smith. 2005. Migratory bird use of belowground foods in moist-soil managed wetlands in the Middle Rio Grande Valley, New Mexico. Wildlife Society Bulletin 33:574-582.

Thompson, S. K. 1992. Sampling. John Wiley and Sons, Inc. New York, USA.

Tubbs, C. R. and J. M. Tubbs. 1983. The distribution of *Zostera* and its exploitation by wildfowl in the Solent, southern England. Aquatic Botany 15:223-239.

U. S. Department of Agriculture. 1968. Mechanical seed cleaning and handling. Agricultural handbook No. 354. Agricultural Research Service.

Waters, T. F. 1969. Subsampler for dividing large samples of stream invertebrate drift. Limnology and Oceanography 14:813-815.

Young, J. A., E. Turner, and L. F. James. 1995. Perennial pepperweed. Rangelands 17:121-123.

VI. Appendices

Appendix A. Screen sizes and other methodology used to separate seeds from detritus for plants sampled from seasonal wetlands at Tule Lake and Lower Klamath National Wildlife Refuge, fall 2002.

Seed	Screen sizes used	Methodology
Saltbush *Atriplex* spp.	6 x 38 (0.016 x 0.151 in)	Blower
Five-hook Basia	18 x 18 screen (0.044 x 0.044 in)	Blower
Meadow Fescue	32 x 32 screen (0.023 x 0.023 in) 6 x 50 screen (0.016 x	 Blower
Mustard	34 x 34 screen (0.022 x 0.022 in) 6 x 50 screen (0.016 x	 Blower
Pepperweed	24 x 24 screen (0.032 x 0.032 in)	Chaff should be ground ≥1 additional time
Pigweed	20 x 20 screen (0.040 x 0.040 in) 6 x 42 screen (0.016 x 0.152 in)	Blower
Pursh Seepweed *(Suaeda depressa)*	12 x 12 heavy screen 18 x 18 heavy screen	

Appendix A. cont…

Seed	Screening	Methodology
Rabbitfoot Grass	36 x 36 screen (0.020 x 0.020 in) 6 x 50 screen (0.016 x	
Red Goosefoot *(Chenopodium botryodes)*	6 x 50 screen (0.016 x 18 x 18 screen (0.044 x 0.044 in)	Rub sheaths using hands and run back through 6 x 50; blower
Smartweed	18 x 18 screen (0.044 x 0.044 in)	Pick remaining seed by hand
Spikerush *(Eleocharis palustris)*	20 x 20 screen (0.040 x 0.040 in) 6 x 30 screen (0.021 x 0.150 in)	Blower
Swamp Timothy	34 x 34 screen (0.022 x 0.022 in)	Blower
Whitetop	20 x 18 screen (0.036 x 0.044 in) 4 x 22 screen (0.033 x 0.230 in)	Blower

Appendix B. Taxon-specific composition (%) of invertebrate samples from seasonal and permanent wetlands. Invertebrate order and, in some cases, family are listed with the exception of Copepoda which were not identified beyond class.

	Seasonal										Permanent		
	Tule Lake		Lower Klamath								Tule Lake	Lower Klamath	
Order Family	DB	S1B	4A	4F	6A	6C	9B	10B	SE	WL	S1A	3A	12C
Hirudinoidea	-	-	-	-	-	-	-	-	-	-	1.3	5.4	T
Oligochaeta	0.2	1.7	55.4	0.7	3.9	19.5	0.3	28.3	0.1	0.2	8.2	1.8	25.8
Gastropoda													
Physidae	-	-	-	-	-	-	-	-	-	-	0.4	-	-
Amphipoda	-	-	-	-	-	-	-	-	-	-	0.7	4.4	0.6
Copepoda	57.2	55.7	21.2	28.6	32.0	20.0	90.5	24.3	69.2	6.2	30.5	28.3	6.6
Anomopoda													
Daphniidae	37.6	20.2	3.6	70.5	46.0	56.3	9.2	42.3	24.9	88.2	46.1	53.0	59.8

Appendix B. cont…

Order / Family	Seasonal: Tule Lake DB	S1B	Seasonal: Lower Klamath 4A	4F	6A	6C	9B	10B	SE	WL	Permanent: Tule Lake S1A	Permanent: Lower Klamath 3A	12C
Levicaudata													
Lynceidae	-	-	2.1	-	0.3	1.5	-	0.7	5.6	-	0.1	0.7	0.6
Diptera													
Chironomidae	4.3	21.7	16.9	0.3	15.7	1.8	-	3.7	-	4.0	9.0	2.5	3.9
Other	-	0.1	0.6	-	0.8	0.1	-	0.4	0.1	-	0.1	0.2	0.4
Coleoptera													
Amphizoidae	-	-	-	-	-	-	-	-	-	-	0.7	-	-
Ephemeroptera	0.5	0.1	-	-	-	0.3	-	-	-	0.9	1.1	3.5	T

Appendix B. cont…

Order / Family	Seasonal										Permanent		
	Tule Lake		Lower Klamath								Tule Lake	Lower Klamath	
	DB	S1B	4A	4F	6A	6C	9B	10B	SE	WL	S1A	3A	12C
Hemiptera													
Corixidae	-	0.1	-	-	0.1	0.1	-	-	-	0.3	-	-	-
Notonectidae	T	-	-	-	-	-	-	-	-	-	-	-	-
Odonata													
Zygoptera	-	T	-	-	-	-	-	-	-	-	2.5	0.2	2.2
Mecoptera	0.1	0.2	-	-	1.2	0.1	-	0.2	-	0.3	-	-	-
Plecoptera	T	T	-	-	0.1	0.4	-	0.2	-	0.1	-	-	-

Appendix C. Tables of mean and 75% percentile waterfowl counts for biweekly aerial surveys flown from 1 September to 15 April 1970-1979 and 1990-1999 at Lower Klamath and Tule Lake National Wildlife Refuges.

C-1. Mean counts of dabbling ducks at Tule Lake National Wildlife Refuge during fall, winter, and spring for a 10 year period during the 1970's and 1990's from aerial surveys.[a]

	1970-1979		1990-1999
Survey Date[b]	75th Percentile[c]	Mean (SE)	Mean (SE)
Sept 1	53,100	43,448	50,434
Sept 15	154,725	116,659	42,943
Oct 1	292,200	213,254	59,467
Oct 15	281,100	305,508	63,467
Nov 1	765,901	472,200	69,630
Nov 15	268,328	262,247	56,293
Dec 1	193,700	121,601	25,153
Dec 15	262,400	168,860	34,728
Jan 1	37,015	30,778	23,908
Jan 15	91,955	53,317	19,825
Feb 1	24,635	19,763	18,019
Feb 15	42,850	41,789	11,297
Mar 1	16,903	15,710	20,256
Mar 15	63,486	51,629	25,725
Apr 1	92,620	77,958	29,733
Apr 15	32,975	25,076	57,120

[a] dabbling ducks include Northern Pintail (*Anas acuta*), Mallard (*A. platyrhynchos*), American Wigeon (*A. americana*), Northern Shoveler (*A. clypeata*), Green-winged Teal (*A. crecca*), Cinnamon Teal (*A. cyanoptera*), and Gadwall (*A. strepera*).
[b] dates are not exact, but surveys were flown approximately every two weeks each year
[c] serves as the population objective for dabbling ducks at TLNWR.

Table C-2. Mean counts of diving ducks at Tule Lake National Wildlife Refuge during fall, winter, and spring for a 10 year period during the 1970's and 1990's from aerial surveys.[a]

	1970-1979		1990-1999
Survey Date[b]	75th Percentile[c]	Mean (SE)	Mean (SE)
Sept 1	4,270	3,680	4,034
Sept 15	2,990	2,663	5,217
Oct 1	6,998	5,775	8,678
Oct 15	10,730	8,671	23,407
Nov 1	16,440	13,800	24,660
Nov 15	11,088	9,594	22,250
Dec 1	3,825	2,494	9,969
Dec 15	2,200	2,024	1,750
Jan 1	193	235	1,138
Jan 15	675	413	775
Feb 1	525	439	4,300
Feb 15	3,115	1,936	5,470
Mar 1	1,308	1,035	4,474
Mar 15	3,388	3,171	2,730
Apr 1	2,555	2,154	1,490
Apr 15	2,638	1,786	606

[a] diving ducks included Canvasback (*Aythya valisneria*), Redhead (*A. americana*), Ring-necked Duck (*A. collaris*).

[b] dates are not exact, but surveys were flown approximately every two weeks each year

[c] serves as the population objective for dabbling ducks at TLNWR.

Table C-3. Mean counts of dabbling ducks at Lower Klamath National Wildlife Refuge during fall, winter, and spring for a 10 year period during the 1970's and 1990's from aerial surveys.[a]

	1970-1979		1990-1999
Survey Date[b]	75^{th} Percentile[c]	Mean (SE)	Mean (SE)
Sept 1	213,521	134,261	145,596
Sept 15	219,869	171,458	238,882
Oct 1	401,738	350,455	345,951
Oct 15	597,010	540,087	541,478
Nov 1	597,536	570,513	680,892
Nov 15	487,361	425,122	542,396
Dec 1	372,560	251,754	326,471
Dec 15	198,118	130,697	140,225
Jan 1	10,594	34,050	93,106
Jan 15	27,171	44,688	154,028
Feb 1	77,714	69,457	107,754
Feb 15	223,459	181,406	214,423
Mar 1	148,414	116,286	274,124
Mar 15	203,306	153,040	336,146
Apr 1	96,775	86,086	122,643
Apr 15	83,339	65,183	105,600

[a] dabbling ducks include Northern Pintail (*Anas acuta*), Mallard (*A. platyrhynchos*), American Wigeon (*A. americana*), Northern Shoveler (*A. clypeata*), Green-winged Teal (*A. crecca*), Cinnamon Teal (*A. cyanoptera*), and Gadwall (*A. strepera*).
[b] dates are not exact, but surveys were flown approximately every two weeks each year
[c] serves as the population objective for dabbling ducks at TLNWR.

Table C-4. Mean counts of diving ducks at Lower Klamath National Wildlife Refuge during fall, winter, and spring for a 10 year period during the 1970's and 1990's from aerial surveys.[a]

	1970-1979		1990-1999
Survey Date[b]	75th Percentile[c]	Mean (SE)	Mean (SE)
Sept 1	2,270	1,815	1,150
Sept 15	1,791	1,727	2,318
Oct 1	3,708	3,207	10,348
Oct 15	7,385	5,199	13,189
Nov 1	6,313	5,084	17,909
Nov 15	5,783	4,099	10,764
Dec 1	1,250	1,090	7,791
Dec 15	855	917	38
Jan 1	160	128	1,338
Jan 15	305	369	1,915
Feb 1	800	730	2,310
Feb 15	2,175	1,503	7,206
Mar 1	1,560	1,173	5,393
Mar 15	1,600	1,463	8,284
Apr 1	3,600	2,484	1,158
Apr 15	2,020	2,195	3,381

[a] diving ducks included Canvasback (*Aythya valisneria*), Redhead (*A. americana*), Ring-necked Duck (*A. collaris*).
[b] dates are not exact, but surveys were flown approximately every two weeks each year
[c] serves as the population objective for dabbling ducks at TLNWR.

Table C-5. Mean counts of geese at Tule Lake National Wildlife Refuge during fall, winter, and spring for a 10 year period during the 1970's and 1990's from aerial surveys.[a]

	1970-1979		1990-1999
Survey Date[b]	75th Percentile[c]	Mean (SE)	Mean (SE)
Sept 1	14,680	13,002	4,174
Sept 15	10,630	12,731	20,391
Oct 1	37,460	27,204	82,831
Oct 15	82,170	54,546	160,334
Nov 1	136,413	97,702	375,931
Nov 15	146,605	121,970	360,294
Dec 1	50,275	38,403	77,632
Dec 15	64,608	43,355	84,993
Jan 1	9,240	7,156	6,378
Jan 15	4,040	2,905	13,544
Feb 1	8,350	4,743	30,990
Feb 15	13,935	14,864	74,234
Mar 1	44,233	38,539	90,590
Mar 15	112,708	99,254	180,306
Apr 1	35,705	33,753	210,663
Apr 15	39,595	32,810	80,338

[a] geese included Lesser Snow Geese (*Chen caerulescens*), Greater White-fronted Geese (*Anser albifrons*), Cackling Geese (*Branta minima*), and Canada Geese (*B. canadensis*)

[b] dates are not exact, but surveys were flown approximately every two weeks each year

[c] serves as the population objective for dabbling ducks at TLNWR.

Table C-6. Mean counts of swans at Tule Lake National Wildlife Refuge during fall, winter, and spring for a 10 year period during the 1970's and 1990's from aerial surveys.[a]

	1970-1979		1990-1999
Survey Date[b]	75^{th} Percentile[c]	Mean (SE)	Mean (SE)
Sept 1	0	0	1
Sept 15	0	0	1
Oct 1	0	14	1
Oct 15	0	57	2
Nov 1	260	234	32
Nov 15	713	589	665
Dec 1	1,230	704	1,533
Dec 15	1,125	873	1,520
Jan 1	640	1,052	1,229
Jan 15	4,205	2,803	460
Feb 1	1,525	1,387	2,075
Feb 15	1,530	1,404	901
Mar 1	1,115	799	799
Mar 15	8	13	576
Apr 1	50	33	116
Apr 15	0	0	17

[a] swans were almost exclusively Tundra Swans (*Cygnus columbianus*)
[b] dates are not exact, but surveys were flown approximately every two weeks each year
[c] serves as the population objective for dabbling ducks at TLNWR.

Table C-7. Mean counts of geese at Lower Klamath National Wildlife Refuge during fall, winter, and spring for a 10 year period during the 1970's and 1990's from aerial surveys.[a]

	1970-1979		1990-1999
Survey Date[b]	75th Percentile[c]	Mean (SE)	Mean (SE)
Sept 1	7,640	10,101	2,674
Sept 15	5,820	5,717	2,770
Oct 1	51,610	39,509	22,124
Oct 15	36,095	25,336	40,051
Nov 1	34,160	30,010	29,957
Nov 15	46,855	33,070	38,619
Dec 1	19,475	17,745	20,488
Dec 15	12,488	9,408	6,243
Jan 1	7,430	6,134	2,312
Jan 15	12,990	9,925	4,611
Feb 1	11,431	7,428	4,033
Feb 15	56,580	37,797	31,484
Mar 1	66,248	57,341	9,991
Mar 15	80,433	67,997	19,013
Apr 1	49,880	39,338	32,996
Apr 15	70,185	55,331	29,515

[a] geese included Lesser Snow Geese (*Chen caerulescens*), Greater White-fronted Geese (*Anser albifrons*), Cackling Geese (*Branta minima*), and Canada Geese (*B. canadensis*)

[b] dates are not exact, but surveys were flown approximately every two weeks each year

[c] serves as the population objective for dabbling ducks at TLNWR.

Table C-8. Mean counts of swans at Lower Klamath National Wildlife Refuge during fall, winter, and spring for a 10 year period during the 1970's and 1990's from aerial surveys.[a]

	1970-1979		1990-1999
Survey Date[b]	75th Percentile[c]	Mean (SE)	Mean (SE)
Sept 1	0	0	1
Sept 15	0	0	2
Oct 1	0	0	2
Oct 15	0	0	3
Nov 1	1,545	1,666	86
Nov 15	3,193	2,114	820
Dec 1	930	683	1,305
Dec 15	1,398	1,166	1,454
Jan 1	2,490	1,774	491
Jan 15	7,211	4,496	2,655
Feb 1	14,043	9,388	3,395
Feb 15	14,960	12,187	6,954
Mar 1	18,995	13,748	7,230
Mar 15	3,186	2,295	3,312
Apr 1	0	190	412
Apr 15	0	0	142

[a] serves as the population objective for Swans at LKNWR.
[b] dates are not exact, but surveys were flown approximately every two weeks each year
[c] serves as the population objective for dabbling ducks at TLNWR.

Table C-9. Mean counts of American Coots at Tule Lake National Wildlife Refuge and Lower Klamath National Wildlife Refuge during fall, winter, and spring for a 10 year period during the 1970's from aerial surveys.[a]

	Refuge	
Interval	TLNWR	LKNWR
Sept 1	31,000	28,000
Sept 15	82,575	33,250
Oct 1	124,900	52,863
Oct 15	115,200	59,925
Nov 1	52,375	23,625
Nov 15	35,925	15,925
Dec 1	10,650	19,500
Dec 15	8,000	5,500
Jan 1	300	540
Jan 15	800	550
Feb 1	2,550	1,750
Feb 15	5,300	8,350
Mar 1	3,750	4,850
Mar 15	12,375	11,000
Apr 1	14,500	45,000
Apr 15	10,250	16,475

[a] numbers serve as the population objective for Coots at TLNWR and LKNWR.

Appendix D. Daily energy requirements by waterfowl guild and date interval for waterfowl on Tule Lake and Lower Klamath National Wildlife Refuges.

Table D-1. Daily bird energy requirements (kcal/day) for a representative bird for each foraging guild at TLNWR for 1970's populations. See methods section of Chapter 2 for list of species in each guild.

Interval	**Dabbling Ducks**	**Diving Ducks**	**Coots**	**Geese**	**Swans**
January 1	311	349	208	730	1106
January 15	304	354	208	733	1106
February 1	294	352	208	635	1106
February 15	276	342	208	616	1106
March 1	279	349	208	528	1106
March 15	271	342	208	521	1106
April 1	269	344	208	523	1106
April 15	264	337	208	509	1106
September 1	279	330	208	791	1106
September 15	284	335	208	561	1106
October 1	284	340	208	530	1106
October 15	286	344	208	514	1106
November 1	294	344	208	493	1106
November 15	291	349	208	493	1106
December 1	299	349	208	530	1106
December 15	286	352	208	523	1106

Table D-2. Bird daily energy requirements (kcal/day) for each foraging guild at TLNWR for 1990's populations. See methods section of Chapter 2 for list of species in each guild.

Time of Year	Dabbling Ducks	Diving Ducks	Coots	Geese	Swans
January 1	313	356	208	758	1106
January 15	335	347	208	711	1106
February 1	299	330	208	648	1106
February 15	276	344	208	685	1106
March 1	258	342	208	532	1106
March 15	240	333	208	530	1106
April 1	230	337	208	532	1106
April 15	235	330	208	546	1106
September 1	296	335	208	556	1106
September 15	291	340	208	583	1106
October 1	279	349	208	571	1106
October 15	281	349	208	518	1106
November 1	264	352	208	497	1106
November 15	271	347	208	497	1106
December 1	291	337	208	527	1106
December 15	294	356	208	621	1106

Table D-3. Bird daily energy requirements (kcal/day) for each foraging guild at LKNWR for 1970's populations. See methods section of Chapter 2 for list of species in each guild.

Time of Year	Dabbling Ducks	Diving Ducks	Coots	Geese	Swans
January 1	304	338	208	755	1106
January 15	299	354	208	662	1106
February 1	299	333	208	773	1106
February 15	276	340	208	640	1106
March 1	281	345	208	650	1106
March 15	276	333	208	554	1106
April 1	261	335	208	534	1106
April 15	253	333	208	504	1106
September 1	276	328	208	973	1106
September 15	279	326	208	945	1106
October 1	335	335	208	680	1106
October 15	286	340	208	539	1106
November 1	286	345	208	523	1106
November 15	286	347	208	547	1106
December 1	296	342	208	681	1106
December 15	289	340	208	787	1106

Table D-4. Bird daily energy requirements (kcal/day) for each foraging guild at LKNWR for 1990's populations. See methods section of Chapter 2 for list of species in each guild.

Time of Year	Dabbling Ducks	Diving Ducks	Coots	Geese	Swans
January 1	311	321	208	755	1106
January 15	301	354	208	680	1106
February 1	286	301	208	804	1106
February 15	276	311	208	708	1106
March 1	266	323	208	563	1106
March 15	243	311	208	559	1106
April 1	222	318	208	546	1106
April 15	224	304	208	542	1106
September 1	294	321	208	912	1106
September 15	290	318	208	904	1106
October 1	269	321	208	629	1106
October 15	261	335	208	601	1106
November 1	264	338	208	611	1106
November 15	261	340	208	574	1106
December 1	276	326	208	609	1106
December 15	311	253	208	780	1106

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Appendix O – Klamath Basin National Wildlife Refuge Complex Cultural Resources Assessment

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Klamath Basin National Wildlife Refuge Complex

Cultural Resources Assessment

May 2011

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Klamath Basin
National Wildlife Refuge Complex
Cultural Resources Assessment

1. Introduction

This section discusses the cultural resources of five of the six national wildlife refuges that make up the Klamath Basin National Wildlife Refuge Complex (NWRC). The five refuges are Clear Lake Wildlife Refuge, Tule Lake Wildlife Refuge, Lower Klamath Lake Wildlife Refuge, Bear Springs Wildlife Refuge, and Upper Klamath Wildlife Refuge. Although it is a part of the NWRC, the Klamath Marsh Wildlife Refuge is excluded from this discussion because it was the subject of a separate CCP.

Based on archival research, two historic properties are known (i.e., are documented in confidential archives) to be on lands within the congressionally authorized boundaries of the Klamath Basin NWRC (excluding Klamath Marsh Wildlife Refuge), the Tule Lake Segregation Center and the Lower Klamath National Wildlife Refuge Historic District; both are currently listed on the National Register of Historic Places (NRHP). Also based on archival research, the following unevaluated cultural resources are known (i.e., are documented in confidential archives) to be on lands within the congressionally authorized boundaries of the Klamath Basin NWRC (excluding Klamath Marsh Wildlife Refuge): 112 recorded prehistoric sites (i.e., worked stone, stacked rocks, cleared areas, bedrock mortars, habitation sites, rock shelters, human remains, pictographs, midden, house pits, traditional use loci) and 28 recorded historic sites (i.e., rock enclosure, structural remains, refuse scatters, battlefields, repatriation locus, Civilian Conservation Corp (C.C.C.) activity loci, miscellaneous structures, railroad grade segment).

Protection measures for properties are keyed to determinations of each property's eligibility for inclusion in the NRHP. Historic properties listed on the NRHP and those determined eligible for listing or with an undetermined eligibility are of concern. Sites that have been formally determined as ineligible are excluded from consideration in future planning processes. The U.S. Fish and Wildlife Service (Service) is required to comply with National Historic Preservation Act Section 106 procedures to avoid adversely affecting historic properties and cultural resources with undetermined eligibility. If an area under consideration for management action has not yet been adequately inventoried for the presence or absence of historic properties, Section 106 requires that the Service identify as-of-yet-undiscovered or unevaluated potentially eligible historic properties.

2. Archival Research

Records and archival searches were conducted in California and Oregon to develop an overview of known cultural resources within the vicinity of the Klamath Basin NWRC. Extrapolating from that record, areas of cultural resource sensitivity were also identified. Additionally, a review of published books, articles, maps, and agency files was conducted in order to form a comprehensive perspective on cultural resources that may not be formally archived, but that could be affected by future Klamath Basin NWRC management activities.

Archival research included a search for information at:

- the California Historical Resources Information System
- the California State University, Chico, Special Collections Library
- the Modoc County Historical Society
- the California Register of Historical Resources (CRHR)
- the California State Historical Landmarks listing
- the California Points of Historical Interest listing
- the National Register of Historic Places
- the National Parks Service National Historic Landmarks Program
- the National Parks Service National Historic Trails
- Oregon-California Trails Association (OCTA)
- General Land Office (GLO) maps and records
- the Oregon Historic Sites Database
- Oregon State Historic Preservation Office (Oregon SHPO) archaeological files
- the Klamath County Historical Society Journals

3. Background

Historically, the Klamath Basin was dotted by approximately 185,000 acres of shallow lakes and freshwater marshes (U.S. Fish and Wildlife Service 2010a). Prominent lakes and marshes in the basin are Agency Lake, Klamath Marsh, Upper and Lower Klamath Lakes, Rhett (or Tule) Lake, Clear (or Wright) Lake, Goose Lake, Albert Lake, Summer Lake, Silver Lake, and Pauline Marsh. There are also a number of small water bodies in the upper reaches of the basin. Numerous depressions, now characterized as marshes and alkali flats, show evidence of former ponding. Major rivers are the Williamson, Sprague, Klamath, Link, Sycan, and Wood. Small perennial and intermittent tributaries, some without natural outlets, occur throughout the basin

The Klamath Basin NWRC provides a variety of habitats, including freshwater marshes, open water, grassy meadows, coniferous forests, sagebrush and juniper grasslands, agricultural lands, and rocky cliffs and slopes. This diversity of habitats and associated natural resources have enticed humans to travel, dwell, and subsist in the basin since as early as 12,000 (Siskin et al. 2009).

Descendants of the earliest inhabitants continue to practice their traditional ways. Contemporary Native American use of the Klamath Basin NWRC includes spiritual quests and the gathering of food, medicine, and basketry materials. The rivers, streams, and lakes still support runs of suckers and the water lily-*wokas* used by Native Americans. The Devil's Garden plateau provides *epos*-root (*Perideridia* sp.) and other plant-foods in addition to deer, antelope, and other game. The nearby mountains and highlands offer other plants for food, basketry, and medicine, and obsidian sources provide an abundance of glassy stone for tools and trade.

3.1 Historic Overview

By 1861, many battles between immigrants and natives had occurred along the Southern Route, or the Applegate Branch of the Oregon Trail. To quell dissent, the region of the Lost River Gap was considered for a military post (National Park Service 2001).

In March 1863, Major Charles S. Drew received orders from the Department of the Pacific to make a reconnaissance survey for the creation of Fort Klamath. After completing his survey, he chose the Wood River Valley near Upper Klamath Lake because of the lush grass that would provide feed for the cavalry horses and the many streams that would supply water (Stone 1990).

In 1864, the Klamath Tribes entered into a treaty (Treaty between the United States of America and the Klamath and Moadoc Tribes and Yahooskin Band of Snake Indians, Oct. 14, 1864, 16 Stat. 707) with the United States whereby it relinquished its aboriginal claim to some 12 million acres of land in return for a reservation of approximately 800,000 acres in south-central Oregon. This reservation included all of the Klamath Marsh as well as large forested tracts of the Williamson River watershed. Article I of the treaty gave the Klamath the exclusive right to hunt, fish, and gather on their reservation, and Article II provided funds to help the Klamath adopt an agricultural way of life. The treaty stated that the Tribes would have "secured" to them "the exclusive right of taking fish in the streams and lakes, included in said reservation, and of gathering edible roots, seeds, and berries within its limits."

The Modoc Indian War began in November 1872 when the United States Army and local militia forces tried to force Captain Jack's band of Modoc Indians, camped on Lost River, back to the reservation established for them in 1864. Unable to co-exist with their traditional enemies, the Klamath, who also occupied the reservation, the Modocs fled the reservation in 1865 to "The Stronghold," a vast lava bed honeycombed with outcroppings, caves, and caverns. They returned to the reservation briefly in 1869, but abandoned it by 1870 (Forest Community Research 2002).

Finally, in April 1873, the army was able to dislodge them from The Stronghold. The Modocs fled south, but, lacking supplies and horses and badly outnumbered, were defeated at Sorass Lake in northeastern California on June 1, 1873. After the defeat, every surviving Modoc who participated in the conflict was marched under guard to Fort Klamath. Six Modoc leaders, including Kintpuash, or Captain Jack, were shackled and held in the guardhouse, while 140 other Modoc men, women, and children were confined to a small stockade.

On October 3, 1873, the Modoc leaders were executed, following their conviction for killing General Edward Canby and other members of a U.S. Army peace commission held at Van Bremmer's Ranch. The remaining Modocs were then exiled to a reservation in Oklahoma or returned to the Klamath Reservation. (Beck and Haase 1974, National Park Service 2001)

After the Modoc Indian War, ranchers, farmers, and business people began to settle the area in earnest, and Klamath County was established on October 24, 1874 (*Herald and News* 1999).

For 20 years, the Klamath lived on their reservation under the terms of the 1864 treaty. In 1887, Congress passed the General Allotment Act (ch. 119, 24 Stat. 388 (1887), which fundamentally changed the nature of land ownership on the Klamath Reservation. Prior to this Act, the Tribe held the reservation land in communal ownership. Pursuant to the terms of the Allotment Act, however, parcels of tribal land were granted to individual tribal members in fee. Under the allotment system, approximately 25 percent of the original Klamath Reservation passed from tribal to individual ownership. Over time, many of these individual allotments passed into non-Indian ownership. In 1900, Fort Klamath was set aside as a recreation area, to be colloquially thought of as the "front door" to Crater Lake National Park. Before that change in status, it was allotted to the Indians, who removed many of the buildings. (National Park Service 2001)

In 1905, the Secretary of the Interior authorized the U.S. Bureau of Reclamation (Reclamation) to initiate the Klamath Reclamation Project for the reclamation of certain lakes and marshes of the Lower Klamath and Tule Lake areas to agricultural lands (U.S. Fish and Wildlife Service 2001). As the wetlands receded, the reclaimed lands were opened to agricultural development and settlement. Today, less than 25 percent of the historic wetlands remain (U.S. Fish and Wildlife Service 2010a).

Also in 1905 in support of the Klamath Reclamation Project, the States of California and Oregon ceded certain lands to the United States, including those under the Lower Klamath and Tule Lakes. As part of the Klamath Reclamation Project, Link River and Clear Lake dams, Lost River diversion, and a host of other dams, canals, and drains were constructed (U.S. Fish and Wildlife Service 2001).

On June 21, 1906, an act of Congress (304 U.S. 119) authorized the Secretary of the Interior to exchange unallotted lands in the reservation for the allotted lands earlier conveyed. The Secretary made an agreement with a land company, pursuant to which on August 22, 1906, it conveyed the

111,385 acres back to the United States; in return, the latter conveyed 87,000 acres of unallotted lands to the company. The Klamath Tribe claimed the transfer was made without fair compensation and contested the decision. The court stated that the obligation of the United States to make good on the plaintiffs' loss was a moral obligation, requiring that any further action be conducted by Congress in accordance with what it shall determine to be right because, except to the extent that Congress may authorize, the government's dealings with Indian tribes are not subject to judicial review (United States v. Klamath and Moadoc Tribes, 304 U.S. 119, 58 S.Ct. 799, 82 L.Ed. 1219 (1938)).

In the midst of the ongoing reclamation of wetlands in the basin, President Theodore Roosevelt recognized the importance of the wetlands to the waterfowl of the Pacific Flyway and established the Lower Klamath National Wildlife Refuge in 1908 by executive order. This was the first refuge established under the National Wildlife Refuge System (System). To conserve much of the basin's remaining wetland habitat, five additional refuges were eventually set aside.

In 1942, the Service and Reclamation entered into an agreement providing for the Service to have jurisdiction and control over the Tule Lake restricted sump, Service areas, and buffer areas to the extent required for wildlife refuge purposes, among other considerations (Weddell et al. 1998); and consistent with the needs of Reclamation's Klamath Project. This agreement responded to concerns that the Service did not have the authority to manage these lands for wildlife (and waterfowl) purposes because they were under the jurisdiction of Reclamation.

The next major change in the pattern of land ownership in the basin occurred in 1954, when Congress approved the Klamath Termination Act of August 13, 1954. Under this Act, tribal members could give up their interest in tribal property for cash. A majority of the tribe chose to do this. An express provision of the act continued the tribal members' right to fish on the former reservation land (Siskiyou County Board of Supervisors District Five 2010).

In 1958, the Service purchased approximately 15,000 acres of the Klamath Marsh, the heart of the former reservation, to establish a migratory bird refuge (Siskiyou County Board of Supervisors District Five 2010).

In 1961, the federal government purchased large forested portions of the former Klamath Reservation. This forest land became part of the Winema National Forest, under the jurisdiction of the U.S. Forest Service (Forest Service). The balance of the reservation was placed in a private trust for the remaining members of the Klamath Reservation (Siskiyou County Board of Supervisors District Five 2010).

Because the Upper Klamath, Lower Klamath, Tule Lake, and Clear Lake Refuges were within the jurisdiction of Reclamation's Klamath Project and were therefore still subject to reclamation, the Kuchel Act of 1964 was passed to effectively stop the conversion of wetlands to farm land, dedicating the refuges "to wildlife conservation and for the major purposes of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith" (U.S. Fish and Wildlife Service 2001).

In 1973, the federal government purchased additional forested tracts that had formerly been part of the Klamath Reservation to become part of the Winema National Forest under the jurisdiction of the Forest Service; to complete implementation of the Klamath Termination Act, the government condemned most of the tribal land held in trust. Payments from the condemnation proceeding and sale of the remaining trust land went to Tribe members. This final distribution of assets essentially extinguished the original Klamath Reservation as a source of tribal property (Siskiyou County Board of Supervisors, District Five 2010).

In 1977, the Service and Reclamation entered into a new agreement for management of the lands leased under the System's farming program. Under the agreement, Reclamation manages the program with the Service retaining ultimate administrative control. (U.S. Fish and Wildlife Service 2001)

In the late 1980s and the 1990s, the listing of the shortnose and Lost River suckers in Upper Klamath Lake and the listing of coho salmon in the Klamath River, development of new scientific information, and heightened awareness of tribal trust obligations related to the Klamath River and Upper Klamath Lake required that the Department of the Interior review operations of the Klamath Project (U.S. Fish and Wildlife Service 2001).

Regional Solicitors for the Department of Interior issued legal opinions on July 25, 1995, and January 8, 1997, that recognized senior water rights of Klamath Basin Tribes and related requirements under the Endangered Species Act. The Klamath Basin NWRC was recognized to be entitled to federal reserved water rights, junior in priority, and to a portion of Reclamation's 1905 Klamath Project water right (U.S. Fish and Wildlife Service 2001).

In 1997, Congress passed the National Wildlife Refuge System Improvement Act, legislation that provides clear guidance for the management of the System. This law directs the Service to manage the System as a national system of land and waters devoted to conserving wildlife and maintaining the biological integrity of ecosystems. It also directs the Service to develop a Comprehensive Conservation Plan for each refuge.

Today, the Klamath Basin NWRC consists of six National Wildlife Refuges: Lower Klamath, Tule Lake, and Clear Lake Refuges in California and Bear Valley, Upper Klamath, and Klamath Marsh Refuges in southern Oregon. The Service manages these refuges to enhance wildlife and benefit the American people in coordination with other state and federal agencies.

The Service is the lead federal agency responsible for federally-listed species under the Endangered Species Act and for migratory birds. Agricultural water programs are coordinated under an agreement between the Service and Reclamation (U.S. Fish and Wildlife Service 2010b). The California Department of Fish and Game and the Oregon Department of Fish and Wildlife are the state agencies responsible for managing fish and wildlife resources in California and Oregon, including state–listed species.

Although the Klamath Tribe no longer holds any of its former reservation lands, the United States still holds title to approximately 70 percent of the former reservation lands. The balance of the reservation is in private Indian and non-Indian ownership, through either allotment or sale of reservation lands at the time of termination. The Klamath Tribe is currently negotiating for the return of former reservation lands.

3.2 Historic Context

This section summarizes historical research undertaken for the Klamath Basin region relative to past peoples and existing knowledge of chronology, settlement, subsistence, and regional interactions. Much of this section is excerpted from *Nature and History in the Klamath Basin* (Most 2003) and is reproduced with the permission of the Oregon Historical Society. Most's work was instrumental in providing a contextual baseline for developing specific research topics. Sections excerpted from Most 2003 are indented.

Trapping. The first non-Native Americans in the Klamath Basin were "mountain men." Traveling from Fort Vancouver on the Columbia River, the western headquarters of Hudson's Bay Company, their objective was to trap as many beaver as possible. The purpose of this London-based company was political as well as economic: not only to sell beaver pelts but also to create a "fur desert" that would leave American trappers with no motive to enter the Oregon territory, which was then disputed between the United States and Britain. (Most 2003)

> Finan McDonald and Thomas McKay arrived in the Klamath Basin in 1825. Like many trappers of their time, they had close relations with Native people or were part Native themselves. An imposing Scotchman, six-foot-four with red hair and a beard, McDonald was married to a Spokane Indian woman. McKay's father was Scotch, his mother a Cree Indian, his wife the daughter of a Chinook chief. Influenced perhaps by the mountain men's ability to relate to Native people, Klamath Indians, upon encountering their party of thirty-two men, warned them to beware of the Indians to the south, the Modocs. (Most 2003)
>
> The next year McKay returned to the Klamath Basin under the command of Peter Skene Ogden. Born in Quebec in 1794 to a Loyalist family that fled the American Revolution, Ogden had trapped beaver from the Great Lakes to the waters of the Columbia. This expedition consisted of two dozen mountain men, who did the hunting and trapping, and their Indian wives, who prepared game and cured hides. Upon reaching Klamath Marsh in December 1826, Ogden encountered what he called the "Clamitte Indian Village," using the Chinook name for the tribe. There Ogden obtained fourteen fish of a kind he had not seen before and nine dogs. Ogden named Upper Klamath Lake "Dog Lake" after his newly acquired food supply. Accompanied by two Klamath Indian guides, the party saw the Klamath River headwaters and looked over the lakes and marshes to the south. Although Ogden found the river disappointingly "destitute of Beaver," his men took hundreds of beaver pelts from its tributaries, the Shasta and Scott rivers, and from streams that flow into them. (Most 2003)
>
> ***Exploration.*** In 1842, when hundreds of emigrants traveled the Oregon Trail to the Willamette Valley, almost all of the land between St. Louis and Oregon City remained unexplored and unmapped. John Charles Frémont, a

skilled surveyor and map-maker, took on the task of filling this gap. (Most 2003)

John Charles Frémont was a southerner. The son of a Virginia woman who left her older, first husband for a handsome French emigré, he grew up in Tennessee, Virginia, and South Carolina. It was Frémont's great fortune to have as his patron and father-in-law Senator Thomas Hart Benton, one of the most powerful politicians of the day. The senator favored a westward expansion of the United States that would wrest Oregon from the British Empire. Benton saw the need for scientific expeditions that fixed latitudes and longitudes and that reported on soil, streams, flora, fauna, and terrain with respect to the land's potential for productive settlement. He had the clout to make Congress fund this work and a son-in-law well able to carry it out. After his first expedition, which went as far as Wyoming, Frémont wrote a report that stimulated interest in westward emigration and built support for exploring beyond the Rockies. His second expedition brought Frémont into Oregon. Turning south from the Columbia and traveling along the eastern slope of the Cascade Range, Frémont's party of twenty-five men, accompanied by Indian guides, reached "a lake of grass" thirty miles north of Klamath Lake in December 1843. There they encountered members of the E'ukskni band of Klamath Indians. The E'ukskni lived in earthlodges, caught fish, and carried bows and arrows. Frémont's men kept a careful guard until they left the Klamath Marsh. Then, heading southeast toward Nevada, the explorers crossed the Sycan River, whose waters flow into Upper Klamath Lake, before spending Christmas Day on the banks of Lake Warner. (Most 2003).

On his expeditions to map the continent, Frémont needed the services of an able scout. Kit Carson, a mountain man who had covered much of the western territory trapping beavers for the fur trade, filled that bill perfectly. "Cool, brave, and of good judgment," Frémont said of Kit Carson in his memoirs, "a good hunter and a good shot; experienced in mountain life, he was an acquisition, and proved valuable throughout the campaign." In 1845 as he prepared to make his third expedition, Frémont knew that he would need Carson's services once again. Although the War Department considered Frémont's expedition "of a scientific character, without any view whatsoever to military operations," the explorer brought with him a well-armed contingent of sixty men, including Carson. When his party came to California, Frémont lingered for months before proceeding to Oregon, as if awaiting new orders. Camped beside Upper Klamath Lake, Frémont learned that a courier, Lieutenant A. H. Gillespie, was on his trail carrying messages from Washington, D.C. Immediately, the explorer formed a party consisting of Carson and nine other men to ride with him, beginning at daybreak, to meet the officer. That fateful encounter, which occurred in a glade at the lake's southern end, has long puzzled historians. Did Gillespie give Frémont instructions to invade California and wrest it from Mexico? His documents did not say so, nor could Gillespie have known that war with Mexico had begun, but he might have told him that war seemed inevitable. Did John Charles Frémont, who had made impetuous decisions before, decide on his own to return to California, bringing a militia that would decide its fate? After questioning Gillespie, then staying up late by the campfire re-reading the letters, Frémont wrapped himself in his blankets, failing, for only the second time in his career, to post a sentry. Near dawn, the sound of an axe striking a man's head awakened Kit Carson, who sounded the alarm. Indians, probably Modocs who had followed Gillespie, rushed the camp. Fighting back, Delaware Indians of Frémont's party killed a leader of the war party and forced his men to flee. The next day, in retaliation, Frémont and Kit Carson attacked and burned a Klamath village, killing 14 men. "I had kept the promise I had made to myself," recalled Frémont, "and had punished these people well for their treachery, and now I turned my thoughts to the work they had delayed." (Most 2003).

Emigration. Traffic over the emigrant route grew in 1849, bringing gold-seekers as well as settlers. The following year, one Modoc assault at the northeastern shore of Tule Lake killed eighty people and inspired a name that would haunt the region: Bloody Point. This massacre gave the Modocs a reputation. Whenever Indians raided a miner's pack train, Modocs were blamed. In 1851, a band of Indians, possibly from the Pit Rivers Tribe, ran off with forty-six mules and horses that miners were bringing into the gold fields. A posse formed to retrieve the animals. Led by Ben Wright, a seasoned Indian fighter, these vigilantes sneaked into a Modoc village, captured women and children, and killed several men.

Modoc attacks at Bloody Point continued. A rescue party, led by Ben Wright, broke up one attack against a wagon train. In 1852, Wright set up camp near a Modoc village on Lost River. With his men hidden nearby, Wright walked into the village, a pistol concealed beneath his serape, and shot the headman. His men opened fire. Only five of more than forty Modocs escaped. The Ben Wright massacre put an end to the Modoc raids, but presaged the tragic Modoc War that broke out twenty years later. (Most 2003)

Treaty. As settlers filled the Upper Klamath Basin, fencing land and putting cattle out to graze, many feared raids by Indians. The Natives had lost access to country where they had hunted game and gathered edible plants. Many were starving. Ranchers and farmers did not want to fight, and with the United States embroiled in civil war, authorities did not want to contend with further massacres or an Indian uprising. (Most 2003)

A Modoc leader, Keintpoos, whom whites knew as Captain Jack, asked the presidentially appointed Indian agent, Judge Elisha Steele, to draw up a treaty. Judge Steele, however, lacked the authority to do this. He may have known that Congress had rejected treaties made with numerous California tribes in 1851 and 1852, allowing their lands to be taken without compensation or legal claim. Nonetheless, Judge Steele made an agreement with Captain Jack to try to establish a reservation in the Tule Lake area. In return, Modocs were to stop stealing livestock. (Most 2003)

Back in Washington, D.C., the Office of Indian Affairs decided to negotiate a different treaty that would remove all of the Indians of the Upper Klamath Basin onto a reservation on the Oregon side of the border. Indian Superintendent J. W. P. Huntington convened over a thousand Indians at a place they called Council Grove, north of Upper Klamath Lake. In return for ceding their traditional territories—more than 20 million acres of south central Oregon and northeastern California, including an expanse of high desert country to the east of the Klamath Basin—Modocs, Klamath, and the Yahooskin Band of Northern Paiutes were to inhabit less than 2 million acres on lands historically occupied by the Klamath Tribe. No whites except for Indian agency employees and Army personnel were supposed to live there. In addition, the Indians were to receive thousands of dollars' worth of supplies over the next fifteen years, after which they were expected to become self-supporting. However, supplies did not arrive for several years—until the Senate ratified the treaty. Even after the goods came, the Indian agent failed to distribute them fairly or fully. As a result, Captain Jack's band of Modocs left the reservation, and the Treaty of 1864 helped to bring about what it was designed to avoid: an uprising, a massacre, and a full-scale war (Most 2003).

Fort Klamath. During the Civil War, the Oregon legislature asked Congress for a military post to keep the Indians of the Upper Klamath Basin under control. In March 1863, Major C. S. Drew surveyed the sites that had been recommended for the new fort. One was not far from the Applegate Trail, where emigrants needed protection; another, overlooking the Link River, lay within the boundaries of today's Klamath Falls; the third was in Wood River Valley north of Upper Klamath Lake. Although this northernmost site was farthest from Bloody Point where emigrants had been killed, Major Drew considered it the best. In addition to having abundant water, ample grass to feed horses and mules, and an extensive pine forest to provide fuel and building materials, this was where the Oregon Central Military Road met the trail between the Rogue River Valley and the mines east of the Cascades. (Most 2003)

Trout and mullet crowded the lakes and streams, and elk, antelope, ducks, geese, and other game offered hunters countless targets. Yet food became a problem once the fort was garrisoned. Long, snow-clad winters isolated Fort Klamath, blocking the supply routes from the California coast and the Rogue River Valley. Indians taught soldiers how to spear fish through ice, but winter fare was rarely fresh. Men dined on dry bread and potato meal, boiled chunks of formerly frozen beefsteak, two-inch-thick squares of "mixed vegetables," and coffee. (Most 2003)

With Linkville—later renamed "Klamath Falls"—thirty-six miles to the south and Jacksonville 100 miles west across the mountains, loneliness and boredom plagued the soldiers. Some ran off, attracted by dreams of gold. If captured, a deserter was court-martialed. If found guilty, he was tattooed with a "D" on his left hip. (Most 2003)

The major problem the soldiers had to contend with was Indians leaving the reservation. Members of the Yahooskin "Snake" tribe ran off the year the treaty was signed. Captain Jack's band of Modocs left in 1870. Because the Modocs returned to their territory south of Klamath Falls, soldiers at the fort were poorly positioned to protect settlers from Indians and Indians from settlers (Most 2003).

Livestock. The lowlands in the Klamath Basin were good for grazing. After 1864, when local Indians were relocated to the Klamath Reservation, settlers, also known as "swamp grabbers," began to dig ditches and bring in cattle. N. B. Ball, a Kentuckian, kept 500 head on a 3,000-acre ranch in Butte Valley. John Fairchild had 3,000 head of stock on 2,700 acres nearby. (Most 2003)

The departure of Captain Jack's band of Modocs from the reservation and their return to their homeland in 1870 troubled the new residents of Modoc country. Some ranchers complained of broken fences and stolen cattle. They said that Modocs who came by their houses asking for food scared womenfolk and children. Other settlers, like John Fairchild and Henry Miller, befriended the Modocs. Contradicting those who claimed that Indians extorted them for "rent" in the form of hay for their horses, Miller maintained that he never paid them a nickel for his land. Instead, he hired them as herders. The rancher also rejected the notion that the Modocs were "hostiles," saying that they "are not more insolent to whites than whites are to whites." At a meeting convened by Major Elmer Otis, the Modoc headman Captain Jack (Keintpoos) announced: "We are willing to have whites live in our country, but we do not want them to locate. . . where we have our winter camps. The settlers are continually lying about my people and trying to make trouble." (Most 2003)

Modoc Indian War. Captain Jack knew that some ranchers were demanding that the Army round his band up and march them back to the reservation. But the trouble came from both sides. Shortly before the outbreak of the Modoc War, Indians stampeded George Miller's 300-steer herd as he drove them from his Langell Valley ranch to Arizona. (Most 2003)

With no order from General E. R. S. Canby, who commanded the Army's Department of the Pacific, or from Colonel Wheaten, who headed Oregon's District of the Lakes, Major Green sent troops from Fort Klamath to Lost

River to bring Captain Jack's band of Modocs back to the Klamath Reservation. The major made this dangerous move after a visit from the reservation sub-agent, Ivan Applegate. Applegate reported that settlers, desperate to get rid of the hundred or so Modoc "desperadoes," might attack Jack's camp on their own. (Most 2003)

When the Army entered the Modoc camp at daybreak, November 29, 1872, an attempt to disarm the Indians sparked an exchange of gunshots. At that moment, settlers came out of hiding and attacked Hooker Jim's village across the river. Several children, two men, and at least one woman died under fire. The rest of the Modocs fled, their destination a natural lavabed fortress south of Tule Lake. On the way, Hooker Jim and his men killed several settlers, including Henry Miller, who had befriended Modocs. Suddenly, war was inevitable. Against the Modoc band, the Army assembled a force of 330 men. Foggy weather and the rugged terrain, however, frustrated the first federal troops. The first assault on January 17, 1872, became a rout, with Modocs shooting at will. That battle left thirty-seven soldiers and civilian volunteers dead or wounded. Not a single Modoc was harmed. (Most 2003)

Knowing that the Army could not dislodge the Indians from their stronghold without great cost in lives, General Canby attempted to negotiate an end to the war. Canby favored a Modoc reservation on Lost River but was not authorized to offer one. While talks continued, the general brought more troops into the vicinity of the Indian stronghold. Failing to get the general to agree even to let Modocs stay in the lavabeds, Captain Jack yielded to pressure from Hooker Jim and other men who had murdered settlers. They feared being hanged as part of a peace agreement and insisted that Canby be assassinated during a negotiation session. On Good Friday, April 11, 1873, the Modoc leader shot General Canby dead. His men killed another peace commissioner, Reverend Eleasar Thomas, and wounded a third, Alfred B. Meacham. (Most 2003)

After Modocs attacked peace commissioners during negotiations, killing General Edward Canby and Reverend Thomas, General George Sherman ordered the tribe's "utter extermination." Shortly thereafter, the Army launched a new assault on the Indian stronghold. Troops cut off the trail between the lavabeds and Tule Lake, their water supply. That night, Modocs fled their natural fortress. (Most 2003)

One party of twenty-two warriors led by Scarfaced Charley did not go far. They ambushed Company E of the 12th Infantry, killing twenty-five and wounding sixteen men. Fears of an Indian uprising swept the countryside. Then four Modoc warriors surrendered. Hooker Jim and three others offered to lead the Army to Captain Jack/Keintpoos in exchange for amnesty. They finally caught up with him in a canyon near Willow Creek. (Most 2003)

The captured Modocs were kept in a stockade within Fort Klamath awaiting the tribunal. Six leaders went on trial. They had no defense counsel. Injured peace commissioner A.B. Meacham testified for the prosecution. Hooker Jim, turning state's evidence, said, "I have been a friend of Captain Jack, but I don't know what he got mad at me for." Captain Jack, speaking in his own defense, recalled going to the lavabeds with a few people after the raid on his Lost River camp. "I had never told Hooker Jim and his party to murder any settlers," he said. Jack added that the four turncoats "all wanted to kill the peace commissioners; they all advised me to do it." The tribunal sentenced Captain Jack and five other men to death by hanging. President Ulysses Grant commuted two of the sentences. After the executions, which occurred on October 3, 1873, the men whose lives Grant spared were imprisoned at Alcatraz. (Most 2003)

The other prisoners of war were put on a train to Oklahoma. At the time, Oklahoma was not a state; it was a territory set aside for Indians. Some Modocs still live there. Others are members of the Klamath Tribe in Oregon. (Most 2003)

Colonialization. In 1852, a brave nineteen-year-old Wallace Baldwin drove fifty head of horses from the Rogue River Valley into the Klamath Basin. He had packed only enough food for his trip along the Applegate Trail, and he had no gun. Klamath Indians helped him survive. They brought him game and taught him how to eat *epaw*, the tuber that was their potato. Baldwin found fertile ground for pasturing his horses and a sunny climate. Although it is unknown how long he stayed, the young man is considered the first non-Indian settler in Klamath country. (Most 2003)

Fifteen years later, George Nurse, a civilian who supplied Fort Klamath with goods, built a small store near the Link River and stocked it with a wagonload of trinkets and necessities. In May 1867, he established a ferry service across the Link River on the trail between the fort and Yreka, California. (Most 2003)

A saloon, a harness shop, and a United States Land Office were among Linkville's early attractions. A pack train brought supplies from Yreka; a stage service provided weekly mail delivery from Ashland. Travelers tied their horses to the hitching post in front of Nurse's Hotel. In 1873, the Modoc War made the town famous across the United States; journalists stayed in the hotel. By 1885, the population had climbed to 384. There were four saloons, three hotels, seven stores, three blacksmith shops, a butcher shop, one newspaper, four doctors, four lawyers, a telegraph office, a Presbyterian church, a flour mill, and a jail. Courtroom space was rented until 1888, when a courthouse and a new jail were built, each costing about $3,500. (Most 2003)

> In 1891, a fire wiped out the buildings near the river. The town was rebuilt, and with its renewal came a campaign to rename Linkville. Two years later, a new city charter named the town Klamath Falls. This name not only suggested a bigger town than any "ville" could be, it connoted the modernity of water power and electricity. Shortly thereafter a dam was built where the upper lake spills into the Link River, obliterating the falls at Klamath Falls. (Most 2003)

The area grew as settlers milled trees into lumber and drained wetlands for ranch and farm lands. With the introduction of water- and steam-driven mills in the 1860s, settlers could begin harvesting and processing the Klamath Basin's abundant timber resources. Water wheels powered the first lumber mills in the Upper Klamath Basin. Those were one-person operations that some of the earliest settlers used. It took them hours to turn a log into planks. Soon buildings clustered from the hillside on the north to the swamps on the south and east.

> ***Timber/Lumber.*** To build Fort Klamath, the U.S. Army brought a steam-driven mill across the Cascades from Jacksonville. It operated from 1863 to 1870 and turned out up to 3,000 board feet per day. The Treaty of 1864 promised "one saw-mill . . . and all the necessary tools and materials for the saw-mill" for the use of the Klamath Tribes. In 1870, the Klamath Agency built a mill that produced boards until it burned down in 1911. (Most 2003)
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> In 1877 William Moore built a mill on the Link River that was able to produce 10,000 board feet per day. Thirty years later his sons opened a mill on the shore of Lake Ewauna, between the Link and the Klamath rivers, that turned out 50,000 board feet daily. But the harvest of logs had hardly begun. The timber industry in Klamath County took off after 1909 when the Southern Pacific Railroad line came to Klamath Falls. (Most 2003)
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> As the fruit industry in California expanded, ponderosa pine was increasingly in demand to make boxes. The Ewauna Box Company, which started work in 1912, became the second largest box factory in the United States. (Most 2003)
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> In 1929, the Weyerhaeuser Timber Company built a huge modern timber mill near Klamath Falls. Its location by the tracks enabled the Weyerhaeuser mill to run year-round. Other mills like the Collier outfit on Swan Lake had to shut down each winter because its horses were unable to haul lumber through the snow to the railroad to get the product to market.

The timber industry has played a major role in the shaping of the economics and landscape of the Klamath Basin, particularly the northern reaches of the Klamath Basin NWRC, which is more forested than other portions of the complex. Throughout the 19th century, timber harvesting was a relatively small-scale operation, producing lumber mostly for local consumption. As water transportation and railroad infrastructure became available, the small-scale operations expanded or disappeared, and large-scale lumber companies, some with East Coast and Great Lakes operational bases, began acquiring large swaths of timberland (Conway and Wells 1994).

The technology of the lumber industry went through several changes during the 19th Century. The tree felling and bucking processes remained the same, a labor-intensive job requiring trees to be cut down with crosscut saws, double-bit axes, wedges, and springboards (Rajala 1989). The yarding and transportation processes tended to change from water- and animal-powered modes to mechanical and steam-driven modes (Rajala 1989). Steam "donkeys," a steam-powered winch for pulling logs to a yarding area, replaced oxen and horses. Logs previously floated downstream on rivers and streams, or hauled by oxen or horses to sawmills, were now transported by logging railroads (Rajala 1989).

Prior to mechanization, mills were small and portable, having to be erected at, or near, the harvest area. Later, logs could be rafted, flumed, or hauled to large-scale permanent industrial mills. The edges of Klamath Basin waterways, with their flat shorelines and still waters, were good places to build mills because logs could be floated to the mills and stored in natural ponds.

Shipping. In 1867, lumber from the Klamath Agency sawmill was purchased by George Nurse to build his store and hotel on the Link River in present-day Klamath Falls. He transported the lumber on rafts across Upper Klamath Lake and down the Link River to his building location. This method of transporting lumber quickly became the method for transporting timber from the reaches around Upper Klamath Lake to the many small sawmills that dotted the landscape around the Link River, Lake Ewauna, and Klamath Falls at the turn of the 20th century (Donnelly 2003a).

In 1877, the Moore Mill, built by William Moore, began operation on the west side of Link River just north of the Link River Bridge in Klamath Falls (Bowden 2002). The sawmill produced lumber from logs that had been rafted from a lumber camp on the western shore of Upper Klamath Lake south to Linkville (later renamed Klamath Falls in 1892). The Moore Sawmill remained in operation until 1907 (Lamm 1944). By 1908, the Ackley Brothers were shipping lumber and hay by raft and barge to Ady, on Lower Klamath Lake, the temporary railhead at that time (Bowden 2002, Helfrich 1965).

John C. Fremont, in 1835, was the first to document watercraft in the Klamath Basin when he noted Indian canoes on Upper Klamath Lake. The first non-native boats to be described in the Klamath Basin were boats (or a boat) either built by Ben Wright's militia, or commissioned by the militia in 1853, to pursue fleeing Modocs adept at water travel (Helfrich 1965).

When Fort Klamath was established in 1863, the supplies had to be brought in from Jacksonville, Oregon, by pack trains of mules and horses over the old Rancheria Trail, which crossed the mountains just north of Mt. Pitt. Later, to shorten the long trek around Klamath Lake, some square rigged "wind jammer" barges were built, one of which was 10 feet by 40 feet, and another 16 feet by 60 feet, to carry the freight from the location of the present Rocky Point Post Office to the old Agency Landing. These barges were sailed on the open lake and propelled by pike poles when on the streams. They were later owned and used by Daniel G. Brown in connection with his ranch at the head of Crystal Creek (Anonymous 1947).

Eventually, as colonialists began to settle the region, ferries were constructed. A newspaper item in the December 31, 1862 *Yreka Semi-Weekly Journal* states: "A ferry has lately been placed at the emigrant road crossing on Lost River…. Considerable travel is expected over this road and ferry towards the Humboldt next spring, and also towards John Day, Powder, and Boise rivers. A bridge has been built over the slough (Lost River Slough, south of present day Henley) for the accommodation of the travel to the Northern mines…" (Helfrich 1965).

An article in the May 19, 1865*Yreka Semi-Weekly Journal* states, ". . . Bob Whittle lately transported 1300 pounds of freight in a boat on the Klamath Lakes towards Fort Klamath. The freight was taken to the lakes from Yreka, and is the first attempt of the kind ever made" (Helfrich 1965).

In 1866, at the head of the Link River, on the old emigrant trail there, a small boat was installed for the use of the Pony Express, designed to carry men and horses only, and just long enough to accommodate a wagon without oxen. At that time the Pony Express, carrying dispatches twice a week between Fort Klamath and Henley (near present day Hornbrook, California) crossed Link River at the outlet of Upper Klamath Lake.

In 1867, George Nurse, founder of Linkville (later called Klamath Falls), ran a permitted ferry across Link River, at approximately the location of the present bridge on Main Street. At about the same time, Wendolen Nus built a cabin and ran a ferry across the river about two miles south of the present city of Klamath Falls, on the east side of Klamath River (Shaver et al. 1905).

Three other early ferries, reported to have plied the Klamath Lakes by 1868, included that of C. J. Dorris, who in 1868, had planned, and maybe built, a ferry on Lost River near to where he ran his cattle; Killibrew's Ferry (made obsolete by construction of Topsy Grade) ran across the Klamath River in Siskiyou County, upstream from Fall Creek, and now is subsumed under the waters of California Oregon Power Company's Reservoir; and there was a ferry at Keno, about one-fourth of a mile below the present highway bridge, or at about the location of Power Company dam below the bridge (Helfrich 1965). Also in 1868, it is reported that Fort Klamath soldiers used "a Whitehall boat" to transport vegetables from their garden at the lower end of Upper Klamath Lake (i.e., Burnetts Point) (Applegate-Good 1941).

The first powered boat in the Klamath Lakes region, built in 1871, made only its maiden voyage before being grounded and thrashed in a storm. It was built by Samuel Grubb, then an employee of the Klamath Reservation. It was a flat bottomed scow about 16 feet by 40 feet for hauling freight across the Upper Lake from Pelican Bay to Kowasta. This boat was propelled by a two-horse treadmill (Applegate-Good 1941).

It appears that at least two boats were probably used to help supply the military campaign during the Modoc War of 1873. Also, at least one boat and several canoes were used to transport soldiers wounded in the fight (Applegate-Good 1941).

In 1872, a small sailboat operated on the Klamath Lakes between the head of the Link River and points north, on the Upper Klamath, Agency Lake, and Williamson River. The keel-bottomed boat, possibly forty feet long and ten feet wide, was owned and operated by a former sailor named Moody. The boat was named either the Mary Moody (for the owner's Indian wife), or Maggie Moody (for Mr. Moody's daughter). Freightage at that time was limited to lumber bought from the Indian Agency and hauled to Linkville, some goods for the stores at the Indian Agency and at Fort Klamath, and, at times, military supplies for the Fort (Applegate-Good 1941).

About 1876, Joe Ball, who was living with an Indian wife, became the owner of the M. Moody, and he continued to operate the boat until about 1879, when H. M. Thatcher and Sykes Worden built the first steam boat on the Upper Klamath Lake, the "General Howard." This steamer, 65 feet long, with 12 foot beam, drawing four and a half to eight feet of water, with 40 horsepower engine and four foot propeller, was built to tow logs from Pelican Bay for the saw mill just built on Link River by W. S. Moore and sons (Anonymous 1947, Applegate-Good 1941).

In 1880, George Loosley and George Nurse bought the General Howard. About a year later, George Loosely bought George Nurse's share.

Associated with George Loosley in the boat business was his brother, John F. (Fred) Loosley (Applegate-Good 1941). In 1884, the two built a flat-bottomed stern wheel boat called the City of Klamath to navigate Wood River (Applegate-Good 1941). The machinery for the boat was salvaged from the General Howard (Anonymous 1947).

About 1897, the Lottie C., another small steamboat or launch which had been operating on the Klamath River between Keno and Klamath Falls, was moved to Upper Klamath Lake. It was owned by a man named Clanton and later operated by Bird Loosley (Anonymous 1947).

In the late 1890s and early 1900s, there were several small boats, mostly barges equipped with steam engines and stern wheels, to do necessary freighting and towing on the lake. These were operated by Baldy Richardson, Louis Dennis, Bert Wilson, Dan Griffith, and others. They bore names like Oregon, Hobson, Alma, Mud Hen, Hornet, Hooligan, North Star, and Eagle (Anonymous 1947).

In the summer of 1904, the largest steamboat to ever ply the lake, the Winema, was built by John Totton and Harry Hansberry, experienced steamboat men from the Columbia River. It was propelled by twin steam engines connected directly to the stern wheel. After her spring 1905 maiden run, a daily schedule was established. The Winema called at every accessible point on the lake, hauling freight of all kinds, and passengers. Each Sunday the boat would be loaded to capacity for a big excursion. The Winema served for many years, being destroyed by fire in 1925, as she lay in drydock in Klamath Falls (Anonymous 1947).

In 1909, the Mazama, a small twin screw steamboat, was put into operation. It ran from Klamath Falls to the town of Fort Klamath, up Wood River, a narrow and very crooked stream (Anonymous 1947).

Also, in the early 1900s, it became popular for people living adjacent to the lake to have personal gasoline-powered boats; each residence had a launch. These boats varied in size from a rowboat powered by a small engine to cruiser cabin launches 35 to 40 feet long (Anonymous 1947).

As the lumber industry on the lakes expanded, a need for more dependable tug boats was apparent, and in 1910 Anton Wickstrom and John Linman built the Modoc. In 1914, after Wickstrom and Linman dissolved their partnership, Captain Linman built the second towboat, the Wasp, 13 feet by 50 feet, with a draught of 26 inches. The machinery for the Wasp had formerly been used in a boat on Tule Lake.

Captain Wickstrom had started a sand business in 1909 to meet the requirements of a rapidly growing city. He towed barges up the lake to the mouths of Williamson River and Wood River, where he delivered sand sucked from the lake bottom. His boat, the Eagle, was steam propelled. During the years that followed, Captain Wickstrom expanded his business to include the hauling of volcanic cinders from Coon Point on the west side of Klamath Lake (Anonymous 1947).

In 1905, the Klamath Navigation Company had built the steamer Klamath on Lake Ewauna for hauling freight and passengers from Laird's Landing to Klamath Falls. It was a double-decker freight and passenger boat with a screw propeller, 75 feet long and 18 feet wide. When the railroad was completed into Klamath Falls, the steamer Klamath was no longer needed for this run and was moved to Upper Klamath Lake for passenger service. Pelican Bay Lumber Company later bought the steamer to use in towing logs to their mill (Anonymous 1947).

Although the Upper Klamath Basin had a rich amount of timberland, shipping the lumber to markets outside the immediate region was complicated by the lack of substantial transportation infrastructure. Freight and wagon roads were generally inadequate for hauling loads of lumber to the nearest railhead near Weed, California, a trip of over 60 miles. Rather, until a railhead was built at Linkville (Klamath Falls), logs were transported as rafts towed by barges (Helfrich 1965). With the development of good highways, motor cars, and trucks, railroading and boating on Klamath Lakes decreased until today only a few pleasure boats and small diesel-powered tow boats are to be seen where the larger craft were once prevalent.

Roads and Trails. Isolation and poor transportation delayed the settlement of the Klamath Basin. The Basin needed good transportation routes over the Cascade Range to the Rogue River Valley and Willamette Valley, and also to railroad points in Northern California to maintain the vitality of towns and homesteads.

> In 1846, Jesse and Lindsay Applegate, together with Leon Scott, headed a party to locate a less dangerous route to the Willamette Valley. Rather than bring families, oxen, and wagons over the Blue Mountains and along the daunting Columbia, the new route would lead emigrants through the southern mountains of the Cascade Range. The road that Scott and the Applegates built went through the Nevada desert, passed Goose Lake, Tule Lake, and Lower Klamath Lake at the California-Oregon border, crossed the Cascades into the Rogue River Valley, then headed north toward the pioneers' destination. (Most 2003)
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> The new road proved to be no easy detour. The first winter that the Applegate Trail was open for emigration came early and caused great suffering. This was the fatal winter of 1846–1847 when the Donner Party came to grief crossing California's Sierra Nevada. It was also unfortunate that the Applegate Trail passed through the homeland of the Modocs. One band of Modocs ambushed emigrants at a place on the edge of Tule Lake that became known as Bloody Point. Although the Applegates built their trail to bring settlers north into Oregon, as soon as word of gold in California reached the newly established settlements, that road became jammed with colonialists rushing south. Trying to stop the flow of emigrants, Modocs attacked wagon trains. Their weapons, however, could not stop the smallest and most lethal invaders: in 1847, at least 150 Modocs died of smallpox. (Most 2003).

The Applegate Road, west of the Klamath Basin, is followed roughly today by Oregon State Highway 66.

When Fort Klamath was established in 1863, the supplies had to be brought in from Jacksonville, Oregon, by pack trains of mules and horses over the old Rancheria Trail, which crossed the mountains just north of Mount McLoughlin (Anonymous 1947). This "Oregon Military Road" parallels Upper Klamath Refuge's western boundary, within 0.1 mile of the refuge.

As time progressed and settlers moved into the Klamath Basin, better roads were established and Linkville (Klamath Falls) was founded (Anonymous 1947). By the end of the nineteenth century, a number of wagon roads radiated from Klamath Falls. All of these roads were used by wagons (i.e., "buggies," freight wagons) at one point or another, and some were used by stagecoach. Roads that joined the Klamath Basin with major outside population centers were of prime importance because new settlers and much-needed commodities were moving over them. Once roads were put into passable condition and as new settlements expanded, a number of stage and wagon routes were established.

The stages carried passengers, mail, and light freight; wagons were responsible for hauling heavier, bulkier freight. The chief purpose of the various routes was to connect Linkville (later named Klamath Falls) with points of the Southern Pacific Railroad (e.g., at Ashland in the Rogue River Valley and at Ager, Thrall, and Montague in California). Other routes reached Lakeview via Bonanza and Bly and Dorris and Alturas in California. The dates of established routes in the vicinity of the Klamath Basin are outlined in Helfrich (1977):

- ***1870***. A stage line from Linkville to Lakeview via Bonanza and Bly (skirting the northern edge of Upper Klamath Lake). This route was probably the route reconnoitered by Captain C. S. Drew from Fort Klamath in March 1864 in search of a road to the Owyhee River and to eastern Oregon after gold was discovered in the area.

- ***1871***. Three routes listed: one from Yreka (within 2 miles of the southwestern boundary of Lower Klamath National Wildlife Refuge); one from Portland via Eugene using the 1863 Oregon Military Road (parallels the western boundary of Upper Klamath National Wildlife Refuge, within 0.1 mile of the refuge); and one from Portland via the Dalles (skirting the western edge of Klamath Marsh and the eastern shores of south Upper Klamath Lake).

- ***1875***. The stage from Ashland to Linkville ran twice a week.

The routes for wagons and stages changed rapidly as new roads were opened or old roads were improved. However, the greatest development of stage and wagon roads occurred after the turn of the century as the population expanded and as roads were improved before the coming of railroads and automobile.

Railroads and Industrial Logging. The first railroad to penetrate the Klamath Basin was built in 1901–1902 from Thrall (in vicinity of Laird's Ranch, within or adjacent to the southern end of Lower Klamath Wildlife Refuge), California, on the main line of the Oregon-California Line (Southern Pacific) for the purpose of serving the lumber mills. Southern Pacific then began construction of a railroad from Abner Weed's industrial sawmill in Siskiyou County, California, to Klamath Falls in 1906 (passing within 0.3 mile of Bear Valley National Wildlife Refuge), incorporating Weed's already existing railroad logging railroad (Bowden 2002). This generated economic development in Klamath Falls as several companies organized and opened mills during this time.

Since construction of the railroad was proceeding quickly, the California Fruit Canners (an association of California fruit and vegetable canning and drying companies and their subsidiaries) established a box factory in Klamath Falls in 1908 and began producing wooden boxes for shipping fruit on the rail lines. (Bowden 2002, History San José 2010)

In 1904, Weyerhaeuser began logging unclaimed timber in the vicinity of Klamath Falls. In 1908, the company had 158,000 acres of active timberlands. The company had cruised the timber long before harvesting, awaiting construction of the railroad before establishing its sawmill four miles southwest of Klamath Falls. (Donnelly 2003b)

In 1909, Southern Pacific completed the rail line from Abner Weed's mill in California to Klamath Falls. By 1911, this line had dead-ended 40 miles north at Kirk (making it partially contiguous with a portion of the Upper Klamath Wildlife Refuge eastern boundary), making the rail line a branch and not the hoped for through-line. (Donnelly 2003b)

Soon after, the Oregon, California & Eastern Railroad (OC&E) was formed, with the intent to connect the region to mainlines and open up more lands for timber harvesting opportunities. Construction of rail lines for the OC&E from Klamath Falls to Sprague River was completed in 1923. (Moore 2010)

Eventually, six other lumber companies began railroad logging operations off the main line, using the OC&E to ship their logs from their decks to Klamath Falls and the many sawmills and factories. By 1948, Weyerhaeuser Timber Company was the only company in the area using rail lines to harvest and haul timber (Moore 2010). During this period, the region was connected to Alturas (1929) and Bieber (1931) in California and Eugene (1926), Bend (1927), and Sprague River (1923) in Oregon by various competing railroad companies (Tonsfeldt 1990).

The improved transportation infrastructure created a boom in lumber companies and timber felling activities. A partial list (Lamm 1944, Tonsfeldt 1990, Bowden 2002, Zilverberg 2002) of companies operating in the northern portion of the Klamath Basin NWRC and reflecting the boom in timber operations includes:

- Ackley Brothers Lumber Company 1904–1943 (taken over by Modoc Lumber Company in 1943)
- Algoma Lumber Company 1911–1943
- Big Lakes Lumber Company 1917–1947
- Blocklinger Lumber Company 1918
- Cascade Box Factory 1930
- California Fruit Canner's Association 1908–1912 (plant eventually purchased by Klamath Manufacturing Company)
- Chiloquin Lumber Company 1912–1947
- Ellingson Timber Company
- Ewauna Box Company 1912
- Klamath Manufacturing Company 1912–1929 (Klamath Lumber and Box Company 1929-1942) (DiGorgio Fruit Corporation 1942)
- Knapp Sawmill 1916–1918 (purchased by Modoc Lumber Company)
- Long Lake Lumber Company 1904

- Lamm Lumber Company 1914–1944
- Pelican Bay Lumber Company 1911–1947
- Shaw-Bertram Lumber Company 1920–1934 (became Modoc Lumber Company)
- Modoc Lumber Company 1946–1995
- Sprague River Lumber Company 1919
- Weyerhaeuser 1900-1992

Many of these companies were small operations, some were shell companies of larger conglomerates and conflicted owners, and a few eventually grew to be considerable economic forces in Klamath County. Many were unable to survive the economic ups and downs of the 1920s and 1930s. If small operations experienced a catastrophe such as a fire (which was a common occurrence), they were sometimes economically devastated and unable to rebuild. While in operation, most of these lumber companies located their mills along the shores of Upper Klamath Lake, Lake Ewauna, Link River, and Lower Klamath Lake. From this vantage point, the companies were able to use water power for transporting logs to their saw mills. This technique was also used during the era of railroad logging.

Throughout the early decades of the 20th century, Weyerhaeuser had been occupying timber tracts throughout the region. Although the company had vast holdings of timber waiting to be cut, the construction of a mill was delayed until a minimum of two rail lines serviced the area. In 1928, the completion of the connecting line to Bend, Oregon, began the process of establishing operations. Weyerhaeuser built a large sawmill and subsidiary operations plants including dry kilns, a box factory, and a planing mill south of Klamath Falls on the west side of Lake Ewauna (Donnelly 2003b). The sawmill opened in 1929 and the other operations opened quickly thereafter.

The early years of the 20th century were years of labor unrest, at times erupting in violence. In 1917 the Martins Brothers flour mill in Klamath Falls was destroyed by arson, an act attributed to sabotage by an Industrial Workers of the World Union (IWW) member (*Evening Herald* 1917). The IWW, created in 1905, had a strong presence in the Northwest forests in the early 1910s, with organized strikes and work slow-downs in an effort to improve lumber camp conditions and create eight-hour work days (Rajala 1989). However, the U.S. government began to prosecute the union members under various laws (Rajala 1989).

Many mills and box factories closed during the Great Depression. In the few years before the United States became embroiled in World War II, the need for lumber on the international market gave a boost to the local economy. After WWII, strong economic growth, affordable mortgages, and an increased demand for housing stimulated the lumber industry (Conway and Wells 1994). This economic boom continued until the mid-1960s, when an economic slowdown coupled with the burgeoning environmental movement and changing forest management practices and regulations reduced the demand for and profitability of lumber (Conway and Wells 1994).

The technology of the lumber industry changed during this time. The technology of the lumber industry changed during this time. The chain saw was invented in the first half of the 20th century and became widely used by the late 1930s in the process of tree felling and bucking. The yarding and transportation processes continued to be by railroad, although trucks began to be used (Rajala 1989). These technological improvements expanded the area of timber available for ready harvest, reduced labor, and reduced the time from harvest to consumer.

3.3 Reclamation, Agriculture, Homesteading

High desert homesteaders often had to rely on unpredictable water sources that flourished and disappeared with the changing of the seasons. In order to sustain the dream to populate the western high desert, the federal government had to initiate programs that would provide irrigation, flood control, land reclamation, and water storage for the homesteaders.

> In 1902, Congress passed the Newlands Act, establishing the Reclamation Service, later renamed the Bureau of Reclamation. At the beginning of the twentieth century, the nationalization of waterways to provide irrigation, flood control, water storage, and power addressed the problem of supporting the West's growing population. One of the first projects of the new Bureau of Reclamation helped settlers farm lands where water *interfered* with cultivation: the marshy, lake-rich terrain of the Upper Klamath Basin and the Lost River drainage. (Most 2003)
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> In order to drain the lakes and marshes and develop a system for moving these waters, Reclamation required the states of Oregon and California to cede to the federal government state rights and title to the region of Tule Lake and the Lower Klamath Lake. Originally, the reclaimed lands were to be sold in 80-acre homesteads. Payments would then subsidize reclamation of other lands. Yet Reclamation neither pressed farmers for their payments nor penalized those who farmed more lands than were allowed. New congressional appropriations provided what Reclamation needed to generate new projects; and, in the Klamath Basin, to build headgates, irrigation canals, ditches, sumps, dams, reservoirs, hydroelectric turbines, and pumps to move the water. (Most 2003)
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> In 1909 three members of the Czech Colonization Club in Omaha, Nebraska, investigated western lands in search of a region suitable for farming. After their journey, Land Committee member Vaclav Vostrcil recommended "the project in Klamath Falls, Oregon for our Czech settlement." Vostrcil expressed his belief that "this country has before it a big future. Lumber for building is cheaper here than in other western countries and water power guarantees the industry of small business." Another sign of the region's big future was the railroad, which had come to Klamath Falls only three months earlier. The undeveloped lands, the Czech farmer reported, sold for thirty dollars per acre, but "everyone has to buy their water rights from the government. These rights cost thirty-five dollars per acre and are payable in ten years without interest." (Most 2003)
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> Frank Zumpfe, who had traveled with Vostrcil on the selection tour, returned to Nebraska and immediately brought his family to the Klamath region. Zumpfe bought sixty-eight acres near Tule Lake. There was a large house and a broken-down barn on his previously cultivated land. Before the year was out, fifty members of the Czech Colonization Club had bought Klamath

Project land. Meeting in the Zumpfe house, the Czechs established a settlement, the town of Malin, which they named for a kind of horseradish that grows in Czechoslovakia. People of Czech descent continue to live in Malin and elsewhere in the Upper Basin. Grandchildren and great-grandchildren of Colonization Club members farm Klamath Project lands today. (Most 2003)

The railroads, wanting to populate their right-of-way in order to carry more freight and raise revenues, advertised that "rainfall follows the plow." When the "Enlarged Homestead Act" of 1909 offered 320-acre land claims to those who would irrigate the desert, speculators started selling future oases near places like Lakeview to gullible easterners. Those who found a lake near their land were the fortunate ones. "The homesteaders had no chance," recalled R. A. Long in his book *The Oregon Desert*. "A homestead is supposed to be farmland—but the desert isn't farmland. Rainfall can drop to as low as five inches a year, which won't raise any known crop. So they were poor, deluded persons. But they were not beaten, bitter, or downtrodden. Against all reason they were happy. . . to a man, they remember their homestead days as the happiest time of their lives." Irrigation drawing waters from Goose Lake helped some homesteaders make a living on the land in the twentieth century. An ironic result is that the lake is no longer visible from Lakeview. (Most 2003)

By 1915, the Klamath Water Users Association had persuaded President Wilson to reduce the Lower Klamath Lake refuge from 80,000 acres to 53,600. Meanwhile, the Bureau of Reclamation used the Southern Pacific railbed as a dike to block overflow from the Klamath River that refilled the shallow lower lake. Its waters quickly evaporated under the abundant sunlight of the Upper Basin. By 1922, a 365-acre pond was all that remained. (Most 2003)

Nesting colonies of migratory wildfowl disappeared. Lands east of the lake became infested with grasshoppers, whose soaring population could no longer be arrested by birds and American Indian gathering. Peat soils started to burn, raising clouds of ash that obscured the skies of Klamath Falls. On October 26, 1922, the Klamath Evening Herald proclaimed: "DUST CLOSES SCHOOLS. Storm Held Worst in History of City: Housewives Aroused!" Finley described what was once Lower Klamath Lake as being "a great desert waste of dry peat and alkali." (Most 2003)

President Calvin Coolidge responded by establishing the Tule Lake National Wildlife Refuge in 1928. In the 1940s, the Bureau of Reclamation built a 6,000-foot tunnel through Sheepy Ridge and pumped runoff water from the Tule Lake Basin up sixty feet into the Lower Klamath drainage. This feat of engineering refilled the wetlands, and birds began to return. By the fall of 1955, an estimated 7 million birds visited the Lower Klamath and Tule Lake refuges, offering innumerable wildlife images for photographers in the Finley tradition. (Most 2003)

Civilian Conservation Corps. In Oregon and throughout the U.S., the Civilian Conservation Corps (C.C.C.) provided much-needed jobs during the depths of the Great Depression. Within the Upper Basin there was a C.C.C. project at Crater Lake, building the infrastructure of the national park there; an Indian C.C.C. on the Klamath Reservation, making trails and doing forest maintenance; two Fish and Wildlife camps at the Tule Lake and Clear Lake wildlife refuges; and two Bureau of Reclamation (BOR) camps on Klamath Project lands. (Most 2003)

C.C.C. Camp BR-41 was quartered two miles north of Merrill, Oregon. Everyday projects included building water control structures of timber and concrete, digging ditches, clearing weeds, and killing rodents. The excavation of J Canal required jack hammers and dynamite; to line the canal workers poured hundreds of cubic yards of concrete. There was emergency work as well. C.C.C. crews fought forest fires like one that scorched Stukel Mountain north of Klamath Falls. When a dike broke and flooded the Tule Lake sump, one crew rapidly repaired the dike; other men, hauling grain from the fields, saved the harvest. (Most 2003)

The daily routine was inspired by the military. Men rose at 6:00 a.m., ate at 6:30, and policed their barracks and camp before starting work at 8:00. At 4:00 p.m., a retreat ceremony signaled the close of the work day. On-the-job training in such tasks as road construction and laying pipelines was available. (Most 2003)

Mr. I. L. Williamson, who conducted a vocational training conference at BR-41, explained to the camp's technical personnel how to teach their skills. Presentation, he said, means that an instructor has to "Tell 'em, Show 'em, Ask 'em, Let 'em talk." Application means, "Let 'em try it." (Most 2003)

All of the men took a course in first aid. Twice a week enrollees from the two BOR camps attended night school in Tulelake, taking classes in reading, writing, spelling, landscape gardening, auto mechanics, history, geography, photography, and journalism. The C.C.C. educational advisor found "a surprising high percentage of enrollees at both camps were illiterate." (Most 2003)

After World War I, Klamath Project plots were given to veterans who applied for them. In the 1920s and 1930s there was more Project land than people who wanted to farm it. (Most 2003)

National Historic Landmark 0600210 "Tule Lake Segregation Center." During World War II, the U.S. War Relocation Authority (WRA) built ten detention centers to detain Japanese Americans living variously throughout

> the West Coast region of the United States. One of these covered 1,100 acres of Klamath Project lands. The government raised 1,000 buildings within a month, detaining 18,000 Japanese Americans at its peak within the Tule Lake War Relocation Authority (WRA) Camp. (Most 2003)

Tule Lake was the largest and longest-lived of the ten camps built by the civilian War Relocation Authority (WRA) to house Japanese Americans removed from the west coast of the United States and imprisoned under the terms of Executive Order 9066 (Most 2003, National Park Service 2006). Many local farmers resented the fact that they lost farming land they were leasing for use of the detention center (Kameda 2010, Most 2003). The camp lacked basic privacy and freedom to come and go as one pleased (Kameda 2010, Most 2003); its toilets and showers were unsanitary (Most 2003).

The government called the concentration camps, to which most mainland Japanese were sent, “Assembly Centers” and “Relocation Centers.” The army rarely referred publicly to Japanese American citizens, but called them, instead, “non-aliens.” Although Franklin Roosevelt was willing to call the camps what they were—concentration camps—in press conferences, American officialdom has resisted this usage. (Daniels 2002)

As the war progressed, the Roosevelt Administration wanted Japanese Americans to serve in the armed forces and began the process of allowing some people to leave the detention centers. First, their loyalty had to be established. All detainees received a long, ambiguously worded questionnaire. Honest answers reflecting the camp experience made many fail the test. Because the Tule Lake Camp had a high rate of those labeled “disloyal” and because it had the size to accommodate more people, it became a camp for “disloyal” (Kameda 2010, Most 2003).

In 1943, Tule Lake was converted to a maximum security segregation center for evacuees from all the relocation centers whom the WRA had identified as “disloyal” (Kameda 2010, Most 2003, National Park Service 2006). Consequently, it had the most guard towers, the largest number of military police, eight tanks, and its own jail and stockade (National Park Service 2006).

> In October 1943, a truck overturned, killing one Tule Lake inmate and injuring others severely. After the camp director refused permission for a funeral service, prisoners went on strike. The WRA brought in strikebreakers from other camps to harvest crops. When the national head of the WRA came to Tule Lake to assess the situation, a mob of more than 5,000 greeted him. Considering the camp out of control, he sent in armed forces with tanks and tear gas. (Most 2003)

In November 1943, the Tule Lake camp was taken over by the army and continued under martial laws until January 1944 (National Park Service 2006).

> For most of the following year, 350 Japanese Americans were interrogated and confined in a newly built stockade within the larger internment camp. No charges were ever filed against them, no hearings or trials took place. In protest, the Japanese government canceled a prisoner-of-war exchange agreement with the U.S. (Most 2003).

The protest from the Japanese government and protests from the California Chapter of the American Civil Liberties Union eventually led to the release of all prisoners held in the stockade (National Park Service 2006).

More historic buildings survive at Tule Lake internment camp than at any of the other “relocation” centers. The extant stockade jail, large sections of the original barbed wire fence, and many of the buildings constructed to house the military police survive to testify to the high security that defined the segregation center. Penciled graffiti inscribed by prisoners survive in the jail. An almost unaltered recreation building and a complex of industrial buildings also survive; there are few examples of either building type remaining at any of the other detention centers. (National Park Service 2006).

This detention center, unique because it became the largest of the ten WRA camps and because it was used to detain those labeled as “disloyal,” was designated a National Historic Landmark in February 2006 for its national importance in the historic context of Japanese Americans in World War II (National Park Service 2006, Kameda 2010). In December 2008, this site was declared a National Monument by Presidential Proclamation (Kameda 2010).

> ***The Lottery.*** World War II veterans competed for Klamath Project farms by participating in a lottery. Those who won got a great deal. In addition to providing free land and supplying water, the government compensated for the low prices farmers received for many crops. As a result, the Klamath Basin remains one of the few regions in the United States where families, rather than agribusiness corporations, run the farms. By the end of the twentieth century, there were approximately 1,400 farms on the Klamath Project, cultivating up to 210,000 acres (Most 2003), making agriculture an important mainstay to the local economy. (Most 2003)
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> ***Post World War II.*** As the postwar-demand for farm products grew, the Klamath Basin supplied potatoes, alfalfa, barley, onions, and other goods, with wildlife refuges doubling as farmland. A similar demand for wood products stimulated growth in the timber industry and spurred the termination of the forested Klamath Reservation. The decline of several wild fish species precipitated a crisis over water use in the Klamath Basin. When the U.S. Bureau of Reclamation cut off water to Klamath Project lands, irrigators and conservationists grew politically polarized even as some farmers and ranchers restored wetlands and practiced efficient irrigation methods. (Most 2003)

While Klamath Falls is the economic hub of Klamath Basin, smaller towns are also affected by visitation and farming on the refuges (U.S. Fish and Wildlife Service 1998). The Klamath Basin NWRC attracts visitors from a wide geographic area due to the great diversity and numbers of wildlife observed there and because of the excellent opportunities for waterfowl hunting on the refuges.

4. Ethnographic Overview

The ethnographic territory of the Klamath, Modoc, and Yahooskin peoples include the modern boundaries of The Klamath Basin NWRC. The Yahooskin are primarily located near Clear Lake. The Klamath and Modoc cultural lifeways are remarkably similar; both groups shared markedly similar linguistic, religious, subsistence, and settlement patterns.

Overall, the Klamath, the Modoc, and the Yahooskin people, who occupied the basin prior to colonization, relied on seasonally available lacustrine plant and animal resources. All three groups, and theoretically perhaps other Native Americans who preceded them, used and depended on a variety of resources in what is now the Klamath Basin NWRC.

Their rock art, both rock paintings (pictographs) and carvings (petroglyphs), are found on cliffs and in caves throughout the Klamath Basin NWRC. Remains of many village sites, rock-works, artifacts, and burial sites have also been found.

Two basic types of *art on rock* are known to be present variously throughout the Klamath Basin NWRC: pictographs and petroglyphs. Pictographs are figures that are painted on rock surfaces. Petroglyphs, in contrast, are figures carved or pecked into the surfaces. Other Native American *rock work* expected within the Klamath Basin NWRC are stacked rock cairns, emplaced rocks, prayer seats, hunting blinds, defensive blinds, rock rings, and areas cleared of rocks.

There is no solid evidence suggesting the age of the rock art in Klamath Basin NWRC; however, researchers (Heizer and Clewlow 1973) have offered some tentative dates that appear to be reasonable. They believe that the pictographs in the area date from about 500 A.D. to 1600 A.D. at the latest (from approximately 380 to 1480 years ago). This latest date is based on the fact that common design elements of the local Native American culture in the historic period are not found (e.g., the horse and other objects introduced by white settlers) in rock art of the Klamath Basin NWRC. It has also been noted that inquiries made to surviving Native Americans in the early part of the century produced no information on the rock art or its creators; hence this knowledge must have passed away in the intervening centuries since its last use. Heizer and Clewlow also concluded that the pictographs were done at a later date than were the petroglyphs in the region.

4.1 The Modocs

The Modoc Indians traditionally occupied both sides of what is now the California-Oregon border. Prior to contact with colonial invaders, the Modocs established permanent camps on and around what are now Tule, Lower Klamath, and Clear Lakes. Their camps near what is now known as the Lost River consisted of groups of temporary domed huts made of tules. Along the waterways they gathered bird eggs, roots and berries, and fish from spring spawning runs. With the coming of summer and the end of the fish runs, the Modocs moved to higher elevations to establish mountain hunting camps from which they hunted mule deer. They gathered nuts and berries from pine trees and manzanita bushes found only at those elevations.

Modoc villages were generally located along Lost River, Lower Klamath Lake, and around the Tule Lakes. A list (Access Genealogy.com 2010a) of ethnographically documented Modoc townsites include:

- ***Agawesh***, at Hot Creek and lower Klamath Lake
- ***Chakawech***, near Yaneks (see in list below), on Sprague River
- ***Kalelk***, on the north shore of Tule (Rhett) Lake
- ***Kawa***, at Yaneks on Sprague River
- ***Keshlakchuis***, on the southeast side of Tule (Rhett) Lake
- ***Keuchishkeni***, on Hot Creek near Little Klamath Lake
- ***Kumbatuash*** (co-inhabited with Klamath), southwest of Tule (Rhett) Lake, extending from the lakeshore to the lava beds
- ***Leush***, on the north side of Tule (Rhett) Lake
- ***Nakoshkeni***, at Lost River and Tule Lake
- ***Nushaltkagakni***, at the headwaters of Lost River near Bonanza
- ***Pashka***, on the northwest shore of Tule (Rhett) Lake
- ***Shapashkeni***, on the southeast side of Little Klamath Lake
- ***Sputuishkeni***, on Lower Klamath Lake
- ***Stuikishkeni***, on the north side of Little Klamath Lake
- ***Waisha***, on Lost River, 3 or 4 miles northwest of Tule (Rhett) Lake, and near the hills that culminate in Laki Peak
- ***Wachamshwash***, on Lost River near Tule (Rhett) Lake, in Klamath County
- ***Welwashkeni***, on the southeast side of Tule (Rhett) Lake, at Miller's Farm
- ***Wukakeni***, on the east side of Tule (Rhett) Lake
- ***Yaneks*** (co-inhabited with Klamath and Yahooskin), along middle Sprague River, Lake County
- ***Yulalona*** (co-inhabited with Klamath), at the site of the present Linkville

The Modoc acquired an unfortunate reputation from frequent conflicts with colonialists. In 1864 the Modoc and the Klamath together ceded their territory to the United States and retired to Klamath

Reservation but they were never contented there and made persistent efforts to return to their old country. Finally, in 1870, a chief named Kintpuash, better known to the Whites as Captain Jack, led the more turbulent element of the tribe back to the California border and refused to return. The first attempt to bring the runaways back precipitated the Modoc War of 1872-73. After the war, part of the tribe was then sent to Indian Territory (Oklahoma) and placed on the Quapaw Reservation and the remainder on the Klamath Reservation. (Access Genealogy.com 2010a)

4.2 The Klamath

The Klamath, who call themselves *Maklaks*, are closely related to the neighboring Modoc Indians. Both the Klamath and the Modoc speak the Lutuami language, which has been assigned to the Klamath-Sahaptin family of the Pneutian phylum. Originally, the Klamath were situated in an area which abounded in marshes and streams (Martin 2006). According to Stern (1965), they lived in a relatively isolated position, with the Cascades to the west, hills to the south and east, and rather harsh territory to the north. The Klamath were first contacted by Euroamericans in 1826. Subsequent settlement and colonialization caused the Klamath to cede most of their aboriginal homeland to the U.S. Government in 1864, and, together with the Modoc and Paiute, they were placed on the Klamath Reservation. Due to extensive intermarriage and migration, the Klamath constituted an “ethnic minority in the communities where they resided, even within the reservation” (Clifton and Levine 1963). There were 2,118 members of the Klamath Tribe in 1955, and 40 percent of them lived off the reservation. As of 1963, 70 percent of the members were less than one-half Indian, and less than one-sixth were full-bloods (Clifton and Levine 1963). In 1954, the membership voted for termination of federal administration of the reservation (Martin 2006).

The Klamath derived most of their subsistence from rivers and marshes. Fish was the staple of their diet, and pond lily seeds were also important. Roots were gathered to some extent. Deer and other game were of minor dietary importance.

The principle Klamath villages were in and around the Klamath Marsh, along the Williamson River, at Chiloquin and around Agency Bay (Portland State University History Department 2001). Apparently each house contained more than one nuclear family, and there was usually some relationship between the members of a household. There was a slight tendency toward patrilocality, and some of the richer men had more than one wife. (Martin 2006)

Permanent winter settlements of earth and mat lodges were located on the banks of rivers. They ranged in size from “several score” to one or two lodges (Martin 2006). In the early spring, the people left the villages for fish runs. In the summer, small bands of two or three families occupied the prairies to collect roots and berries and other edible plants. Toward the end of the summer, the pond lily seeds ripened and the people gathered together at the marshes to harvest them. They returned to the same winter villages year after year. It has been estimated that, aboriginally, the Klamath numbered between 800 and 1,400 (Martin 2006).

There were five or six geographical divisions of the Klamath. The largest one was in the vicinity of Klamath Marsh. Other groups lived in the vicinity of Agency Lake, the lower Williamson River, Pelican Bay, Klamath Falls, and the Sprague River Valley. There was some tendency toward endogamy within these divisions, but there was no political unity. (Martin 2006)

Warfare, feuds, and slave raiding took place between the subdivisions of the Klamath and with non-Klamath. Some reports state that the Klamath conducted slave raids yearly against the *Achomawi* and other Pit River Indians. Kroeber (1953), however, felt that these reports were very exaggerated.

Headpersons of the villages were people who had acquired prestige. Most of Spier's (1930) informants indicated that shamans were of greater importance to the community than the headpersons. (Martin 2006)

Every Klamath sought spiritual power in vision quests, which took place at life crises such as puberty and mourning. The spirits primarily are in the form of nature spirits or anthropomorphic beings. Shamans are people who have acquired more spiritual power than most. (Martin 2006)

Shamanistic performances, during which the shamans became possessed, were the main form of ceremonialism among the Klamath. These performances were held in the winter and lasted five days and nights. In addition to curative functions, the shamans' services could be invoked at any time during the year for such purposes as prophesy, divination, or weather control. Klamath mythology is dominated by the culture hero *Kemukemps*, a trickster figure who created men and women. (Martin 2006)

Klamath ethnographic territories were centered near annual settlement locations throughout the Klamath Basin, including the northern portion of Lower Klamath Lake, Upper Klamath Lake, Klamath Marsh, Agency Lake, and Crater Lake. Communication and trade carried Klamath peoples as far north as The Dalles along the Colombia River and as far south as the Tule Lake Basin. The river drainages of the Sprague, Rogue, and Deschutes Rivers were also considered important seasonal extensions of the Klamath territory. Modoc ethnographic territories were centered near the Lower Klamath Lake Basin and the Tule Lake Basin, with the largest annual settlements located near Lost River. Modoc territories spanned as far east as Goose Lake and included Medicine Lake to the southeast. Tribal boundaries and territories remain the subject of a heated debate amongst ethnographers, especially as diverse resource procurement and trade as well as culturally defined rights to land access have blurred rigid intertribal boundary establishment. Both Klamath and Modoc peoples used extensive trade routes and were notorious for venturing into neighboring Native territories for resource procurement and for capturing slaves who were often used for commodity in trade relationships with tribal groups to the north. [For more on ethnographic territories, see Gatschett 1890, Barrett 1910, Kroeber 1916, Spier 1930, Cressman 1956, and Stern 1998).

Resource procurement was centered on permanent bodies of water, perhaps most notably the Upper and Lower Klamath Lakes, Klamath River, Williamson River, Deschutes River, and Lost River and their tributaries. Seasonal variability of fish species lent itself well to the Klamath-Modoc exploitation of fishing resources year-round. Salmon (king/Chinook salmon, *Oncorhynchus tschawytscha*, and the silver/coho salmon, *O. kisutch*), sucker fish (Lost River sucker, *Deltistes luxatus,* and shortnose sucker, *Chasmistes brevirostris*) and trout (redband trout, *Salmo newberrii*) were the most common varieties fished for food. The establishment of weirs and the use of fishing lines, hooks, and nets were common fishing techniques. Other freshwater resources included freshwater mussel species (*Anodonta* and *Margaritifera*), waterfowl, and a wide variety of plant species, including yellow pond-lily (*wokas*, *Nuphar polysepalum* and *Nuphar lutea*), cattails (*Typha latifolia*), and tule reeds (*Schoenoplectus* and *Scirpus*). Many species of grasses, berries, pine trees, mushrooms, and other herbaceous plants were also collected seasonally for a wide variety of purposes. Although both populations also practiced seasonal hunting of migratory herds of deer, antelope, and elk, the Klamath peoples relied more on fishing than hunting. Where available, muskrats, otters, beavers, rabbits, and other small fauna were also used as food and material resources.

Settlement practices of the Klamath and Modoc reflected their different methods of resource procurement, with the Klamath tending to focus more on fishing resources and the Modoc tending to focus more on game hunting. Both Klamath and Modoc peoples practiced a seasonally based settlement pattern that was dependent on weather and the seasonal availability of food and material resources. The Klamath typically would establish permanent winter villages that were used by returning families year after year. General village affiliation was determined by these winter villages, often composed of several patriclans. Each domicile was constructed to hold a minimum of 12 to 20 individuals, often representing extended and/or joint families related through a patrilineage. Klamath village members would often return from temporary campsites established in higher altitudes in late August or early September, corresponding with the ripening of the yellow pond lily seed bulbs, a staple food source that was collected and prepared in a wide range of recipes, depending on the quality and content of the seed harvest. Winter settlement allowed for the gathering, drying, and processing of the *wokas* seeds, which were then stored for later use, especially as temperatures in the Upper Klamath Lake Basin dipped below freezing during the coldest months of winter (Coville 1904).

Typically, Klamath winter houses were semi-subterranean structures to a depth of three to four feet, with semi-conical elongated roofs, made of log support beams and rafters, covered with woven tule mats and sod or piled earth for insulation, and overlapping planks for roofing materials. Winter houses were built large enough to house several individuals and to provide storage of food and other important material items. Houses varied in size from 12 to 35 feet in diameter, depending on the size of the family and the social position of its members. Often shamans would have larger houses, as large as 50 feet in diameter, to accommodate religious functions. In the spring, these winter houses were dismantled. Sometimes a similar structure would be constructed for residence during the remainder of the year, having a more open plan with woven tule mats providing the main exterior. Summer houses were typically built either at ground surface or in shallow one to three foot pits, and had a circular floor plan. Each village also constructed auxiliary structures, including menstrual huts, granaries, cook houses, and sweat lodges.

Other forms of Klamath material culture have been well documented in the archaeological record of prehistoric and contact-period populations. Connected to their seasonal sedentism and the process-intensive lifeways, Klamath peoples manufactured groundstone implements, including metates, manos, pestles, mortars, and distinctive double-horned mullers; flaked stone implements, such as bifaces (spearheads and knife blades), projectile points (atlatl darts, spear heads, and arrowheads), drills, core tools (choppers), flake tools (scrapers); and bone and antler implements, such as wedges, awls, and stone-flakers (Gatschett 1890). Klamath populations also were adept at basketry, constructing various items from numerous species of tule, cattail, and grasses, including bowls, hats, carrying vessels, storage vessels, winnowing trays, gambling trays, ladles, seed beaters, and fishing nets (Barrett 1910, Heizer and Whipple 1951, Spier 1930). On the Upper Klamath the preferred boat form was the hollowed-out log canoe, while on the Lower Klamath and Tule Lake, tule reed rafts were preferred. Of particular interest are the occasional discoveries of "*henwas*," anthropomorphic stone figures, often found in pairs, said to represent spirits used particularly by shamans (Carlson 1959, Spier 1930). Other forms of material culture related to beliefs in the supernatural include numerous panels of both pictographs and petroglyphs and concentrations of rock stacks, cairns, and alignments, all related to vision/power quest activities (Caldwell and Carlson 1954, Chartkoff and Chartkoff 1984, Spier 1930).

The Klamath belief in the supernatural centered around two generalized characterizations of supernatural beings: spirits and ghosts. Spirits were generalized supernatural beings who had not taken human form, but were often referents of various kinds of fauna and climatic occurrences typically present within the environment of the Klamath. Although spirit beings could not be classified as deities per se, they did have the effect of altering natural events, such as bringing storms, causing earthquakes, and generally providing cause for empirically visible anomalies in the weather and landscape. Typically, it was to these spirit beings that those undergoing vision/power quests would supplicate themselves in order to receive power via altered states of consciousness and dreaming. These supernatural beings provided an example through the stories told about them for important social constructions such as ethics, mores, taboos, and general causal explanations. Some examples include Thunder, Falcon, Crow, Weasel, Mink, Dwarf Old Woman, and, *gmok'am'c* (the Creator), the Klamath culture hero (Spier 1930, Stern 1998). Ghosts were perceived as being those supernatural beings who after having been humans during life had neglected their passage to the Land of the Dead to the west, and had remained within reach of living human populations, coveting their lives. (Spier 1930, Spencer 1952)

The primary religious specialists for the Klamath and Modoc were shamans. Shamans maintained roles as community curers and ritual specialists, often afforded a special and heightened social regard due to their liminal relationship with the supernatural. Shamans obtained their powers via a direct relationship with the supernatural, often procured after extensive and repeated vision/power quest rituals. The shaman's power was viewed as great enough to influence the weather and predict future events. Shamans often also worked with various assistants who would serve as interpreters during singing, or to supplicate supernatural beings to provide their influence to the shaman's requests. The cold and dark winter season would lend itself to shamanic performances of myth.

All members could practice vision/power quest, and most had their first experience at puberty. Males more frequently performed the ritual. However, women did also, mostly after menopause had begun. It was imperative for those who were to become shamans to perform the ritual. The power quest ritual required swimming in deep pools and eddies of rivers, and generally avoiding the feeling of being afraid. The ritual consisted of spending time alone for several days, sleeping at night exposed to the elements, fasting, swimming in various standing and running bodies of water, running, piling rocks, and dreaming. Conscious awareness of dreams was stressed and the messages that they portended were thought to be messages from supernatural realm. An especially auspicious sign was the occurrence of a nosebleed or hemorrhage, which was taken as a sign that one had had contact with the supernatural. Information was translated into songs, which were sung publicly later, often accompanied by dance. It was the song that was the conduit for the power gained by the person. (Bradbury et al. 2004)

4.3 The Yahooskin

The Yahooskin are a Yuman-speaking band of Shoshoni who, prior to 1864, roved and hunted with the Walpapi about the shores of Goose, Silver, Warner, and Harney lakes and in Surprise Valley and Klamath Marsh, where they gathered *wokas* for food. In 1864 they became party to the treaty of Klamath Lake by which their territory was ceded to the United States and they were placed on the Klamath Reservation, established at that time. With the Walpapi and a few Paiute who had joined them, the Yahooskin were assigned lands in the southern part of the reservation, on the Sprague River at about Yainax, where they have since resided. Gatschet, who visited them about 1884, says they were then engaged in agriculture, lived in willow lodges and log houses, and were gradually abandoning their seasonal subsistence-gathering strategy and becoming more sedentary on the reservation. (Access Genealogy.com 2010b)

5. Prehistoric Overview

Based on archaeological evidence (Tribal historians and others may cite more ancient occupation), the prehistory of the Klamath Basin dates as far back as 12,000 to 13,000 years ago. There are several patterns of cultural adaptation generally recognizable in the prehistoric chronology (Siskin et al. 2009). Archaeological resources identified to date within the Klamath Basin NWRC consist of pre-historic, historic, and multi-component sites containing both pre-historic and historic elements. The following pre-historic chronology is presented as an overview of the types of pre-historic resources located within the Klamath Basin NWRC.

5.1 Paleoarchaic (12,000 to 7,000 B.P.)

During the Paleoarchaic period, the Klamath Basin was occupied by hunter-gatherers with a broad-spectrum subsistence economy geared toward large game animals and supplemented by fish, birds, and plants. High seasonal and annual mobility, low population densities, and a technology geared toward maximum flexibility define these people (Ames et al. 1998). The oldest site in the region is the Fort Rock Cave site in south-central Oregon. This site was excavated by Luther Cressman in the 1950s and has produced radiocarbon dates of between 13,200 and 10,200 B.P. (Aikens 1993); however, the charcoal that produced the earliest dates may not be cultural in origin (Ames and Maschner 1999). From within the Upper Klamath River Basin, the oldest reliable radiocarbon date is from the Klamath Shoal midden site (35KL21), dating to 7,700 years ago.

5.2 Early Archaic (7,000 to 4,500 B.P.)

Most of the archaeological evidence for early human occupation within the Klamath River canyon extends back to the beginning of the Early Archaic (Mack 1983 and 1991). This period saw the first appearance of semisubterranean house pits in the Plateau region, indicating that some people were adopting a less mobile lifestyle. The Early Archaic corresponds to the Secret Spring Phase and the Basin Phase (Mack 1991):

- Secret Spring Phase (7,500 to 6,500 B.P.). Artifacts typical of this phase include large stemmed or lanceolate projectile points, knives, gravers, scrapers, and some cobble and ground stone tools, including abraders or grinding slabs.

- Basin Phase (6,500 to 4,500 B.P.). Typical artifacts of this phase include ground stone tools, large leaf-shaped and broad-necked projectile points (Humboldt Concave Base, Northern Side-Notched) indicating atlatl technology, utilitarian items (portable mortars, mullers, and stone bowls), cores, gravers, knives, scrapers, and unifaces. Faunal remains include turtles and large to small mammals. Burial practice was supine burials placed in rock-covered pits.

5.3 Middle Archaic (4,500 to 2,500 B.P.)

The shift toward sedentary life appears at Nightfire Island about 4,000 years ago. The Middle Archaic saw an increase in the exploitation of riverine and marsh environments (salmon and root species), as indicated by an increasing presence of milling stones and pestles at sites. The Middle Archaic includes the River Phase (Mack 1991):

- River Phase (4,500 to 2,500 B.P.). Artifacts typical of this phase include broad-necked corner-notched and side-notched projectile points (Class 28, Elko series, Gold Hill Leaf, Siskiyou Side-Notched), many types of ground stone tools, bone and antler tools (chisels and wedges), and specialized fishing gear (bone harpoon barbs and net sinkers). Faunal remains at sites of the River Phase tend to be dominated by riverine resources. Burial practice shifts to flexed burials.

5.4 Late Archaic/Late Prehistoric (2,500 to 200 B.P.)

Several major changes occurred during the Late Period, including the widespread appearance of pit houses, the shift to heavy reliance on fishing (specialized fishing gear included net sinkers and harpoons with barbed points), the use of storage pits for salmon, camas exploitation, and the development of seasonal ("winter village") land use patterns. It is at this time that the bow and arrow were adopted (indicated by the presence of small corner- and side-notched projectile points at sites). Site patterning suggests that a gradual shift toward the exploitation of riverine and marsh aquatic resources occurred during this period. Logistical camps were in use in the area by about 2,000 years ago, as evidenced by the Williamson River Bridge site. Extensive trade networks became important by at least 1,500 years ago, as suggested by obsidian tools present in the Nightfire Island artifact assemblage derived from sources as distant as the Warner and Quartz mountains, 110 to 120 miles away (Aikens 1993). Mack (1991) clarifies that the Late Period includes two of the Upper Klamath River Canyon phases: the River and Canyon phases (NOTE: Mack further divides the Canyon Phase into three sub phases):

- Canyon Phase (2,500 to 200 B.P.). This phase includes each of the sites with house pits in the Klamath Canyon. Typical artifacts of the phase include small, narrow-necked projectile points (Desert Side-Notched, Gunther, and Rosegate series) indicating the adoption of the bow and arrow, specialized mullers for processing wocus, numerous bone tools, and Olivell shell beads. Burial practice shifts to cremation with associated grave goods such as mammal bone beads and elk antler spoons.

6. Archaeological Resources

This section, based on Federal Energy Regulatory Commission (2007) studies for the region, summarizes the available data on American Indians in the Upper Klamath River and Basin regions. Previous work by Mack (1983, 1989, 1991) and others (Gleason 2001, Hannon and Olmo 1990, Leonhardy 1967, Oetting 1996) in the Klamath River canyon; previous work by researchers in the Upper Klamath Lake and Upper Klamath Basin regions (Cressman 1956, Sampson 1985), and past research in immediately adjacent areas (Aikens and Jenkins 1994, Cleland 1997, Fagan et al. 1994, Nilsson 1985, Oetting 1993, Raven 1984, Ritter 1989) provide a contextual baseline for developing specific research topics. This section details archaeological research for the region relative to past peoples and existing knowledge on chronology, settlement, subsistence, and regional interactions.

6.1 History of Archaeology in Region

The earliest archaeological work in the region was conducted in 1935 at the excavation of Fern Cave in northern California by D. H. Canfield and J. C. Couch (Moratto 1984). Luther Cressman dominated regional archaeological investigations for the next 20 years. From 1938 to 1940, Cressman excavated several sites in the Klamath Lake Basin and introduced a cultural-historical interdisciplinary approach to the archaeological research of the region, stressing the discovery of areal patterns and their chronologies. He defined three cultural phases (horizons) for the lower Klamath Lake region as: (1) *the Narrows* (10,000 to 7,500 B.P.), which was characterized by willow-shaped projectile points and associated with extinct fauna, (2) *Lairds Bay* (beginning ca. 4,000 B.P.), which was characterized by large side-notched and corner-notched projectile points, and (3) *Modoc* (1,500 to 1,000 B.P.), which saw a reduction in the size of projectile points (Moratto 1984).

In the late 1950s, Cressman directed the University of Oregon's John C. Boyle dam excavation program. At Rock Shelter Site 35KL13, the excavations recovered cultural materials similar to the Kawaumkan Springs midden site in Klamath Basin, plus three fragments of poorly fired pottery (Gleason 2001).

Surveys and excavations associated with the proposed (but never constructed) Salt Cave reservoir were undertaken by the University of Oregon in 1961 to 1963. The surveys identified 12 canyon sites, of which three were test-excavated (including Big Boulder Village 35KL18, where significant quantities of pottery were recovered).

Additional survey and testing followed in the 1980s when a new proposal to construct Salt Cave dam was under consideration. Twenty sites in the Klamath Canyon were test-excavated during the course of an attempted (but not completed) FERC licensing process for the proposed Salt Cave dam.

In 1980, BLM surveys (Mack 1991) along the Klamath River in California resulted in the recordation of two pit house village sites: the Freedom site (CA-SIS-1721) and the Laubacher site (CA-SIS-2241). Subsequent BLM land exchange surveys resulted in the identification and testing of several sites in this area (Oetting 1996). Beginning in 1992, Mack and her students conducted archaeological research in the Upper Klamath River watershed, excavating at least 12 sites, including temporary camps, lithic scatters, and other nonvillage site types (Gleason 2001). Most of the recent work in the canyon has been conducted pursuant to cultural resource management projects (Gleason 2001).

6.2 Selected Regional Sites

Results from several larger excavations and data sets available from sites in the region provide a good sample of the range of recorded human use patterns found in and near the Upper Klamath River. These sites and others have influenced the general overview developed by archaeologists.

Kawumkan Springs Midden and House Pits (35KL9). This site, located northeast of Upper Klamath Lake, was excavated by Cressman in 1956. The site was originally estimated to date from 6,600 B.P. but has more recently been determined to date to about 4,200 B.P. (Aikens and Minor 1978). Cressman showed that the subsistence economy practiced early in the occupation of the Kawumkan Springs midden site was similar to Northern Great Basin culture, but over time the economy gradually shifted toward dependence on fish and on the exploitation of wocus (evinced by the use of special mullers) (Mack 1991). Thus, the Kawumkan Springs midden site data demonstrate the split in local cultural development away from the Northern Great Basin patterns.

Williamson River Bridge (35KL677). This fishing station site, northeast of Upper Klamath Lake, was excavated by the University of Oregon (Cheatham 1991). The site included a shell midden with a hearth and several concentrations of fire-cracked rock. One of the concentrations was radiocarbon dated to 1,810 B.P., another to 70 B.P., and the midden to 1,600 B.P. Historic artifacts present at the site and additional radiocarbon dates indicate that the site had two occupations: a prehistoric occupation dating between 1,800 and 100 B.P. and a historic occupation dating to about 100 years ago. Three wooden posts near the hearth feature were interpreted as part of a fish-drying rack. Faunal analysis revealed that 84 percent of the remains are fish (96 percent suckers), 15 percent are mammals (mostly ground squirrel and domestic dog), and 1 percent are birds. Analysis of freshwater mussel shells (4,500 individuals represented) indicates that the season of death was between mid-April and mid-June, corresponding to the annual sucker spawning runs (Aikens 1993).

Nightfire Island. Johnson excavated this prominent site located on the shores of Lower Klamath Lake in 1969. The site has a long sequence of occupation (ca. 6,000 years). Johnson identified a deeply stratified occupation deposit (maximum 3 meters deep) with the full range of activities represented in the rich assemblage. Recovered artifacts include woodworking tools; hunting, butchering, and hide preparation tools; grinding implements; burials; and domestic structures. Faunal analysis demonstrated that animal exploitation continued unabated throughout the site's occupation, contradicting Antevs' (1955) Altithermal-Medithermal climatic sequence (Grayson 1973). Grayson suggested that the assumed long, hot drought of the Altithermal in the Klamath Basin had little effect on environment or culture at the Nightfire Island site (Moratto 1984). On the other hand, Sampson (1985) interpreted site data to represent an adaptation to the changing lakeshore environment. Sampson suggested that the site function shifted from an intermittently occupied campsite (6,000 to 4,300 years ago) to a sedentary village (4,300 to 3,000 years ago) and back to a campsite (post-3,000 years ago). X-ray fluorescence (XRF) analysis of nearly 300 obsidian artifacts from the site shows changing regional interactions, with people of Nightfire Island demonstrating greater contact with groups living to the north and east, prior to their adoption of the bow and arrow. Aikens suggested this represented a response to local competition that forced the Nightfire Islanders to look to outlying sources for obsidian (Aikens 1993).

Tule Lake. Robert Heizer excavated the cave sites at Petroglyph Point on the shores of Tule Lake in northeast California in 1942. As a result of the excellent preservation in the cave, the recovered artifact assemblage contained many perishable items, including Olivella beads (spirelopped and saddle types), Haliotis shell blanks, seed beads, basketry (single- and plain-twined), matting fragments, cordage, bird bone beads, worked antler, and a wooden bow fragment (Heizer 1942). However, Heizer concluded that the assemblage was not very old, probably dating to the ethnographic era. The surrounding area reportedly also contained crevice burials, cremations, and caches that were excavated by private collectors.

Klamath River Bridge Cemetery (35KL1121). This village site, located near the city of Klamath Falls, was excavated in 1993 by the University of Oregon. The village included an adjacent cemetery that, based on projectile point styles and shell bead types and frequencies, was occupied sometime between A.D. 300 and 1500. Exotic materials present at the site indicate the regional interactions with groups in northern California (Tasa and Connolly 1997).

Keno Pictographs (35KL1901). This rock art site is located in the Upper Klamath River canyon near the town of Keno. The site includes a diverse collection of images that is believed to demonstrate regional interactions between Klamath/Modoc and Shasta peoples (Ritter 1999).

Big Boulder Village (35KL18). This pit house village was excavated by the University of Oregon from 1961 to 1963 as part of the proposed Salt Cave reservoir project. One occupational floor was radiocarbon dated to ca. 560 years ago (Mack 1983). Several burials were recovered from the midden portion of the site, with both flexed and extended burials present. The artifact assemblage at this site is typical of late prehistoric assemblages in the region.

Klamath Shoal Midden (35KL21). This early site was also excavated by the University of Oregon from 1961 to 1963. The site contains the earliest reliable evidence of occupation in the Klamath canyon (7,700 years ago). Bone tools, unifacial flake tools, and turtle and mammal bone represent the early occupation. The site’s extensive midden represents a later occupation, producing radiocarbon dates of ca. 1,330 to 1,040 years ago. Artifacts recovered from the midden include projectile points (mostly Gunther and Rosegate series, with Alkali stemmed also present) and other chipped stone tools; Olivella shell beads; a Haliotis pendant; ground stone tools (hopper mortars, pestles, and metates); steatite pendants and a pipe; and fired clay objects. Cultural features include burials, stone-lined cache pits, and rock and bone clusters (Mack 1983). These artifacts and features represent the intensive use of this site, with additional sites in the area that echo this local settlement intensity.

Border Village (35KL16). This was another pit house village excavated by the University of Oregon from 1961 to 1963 as part of the Salt Cave reservoir project. One occupational floor was radiocarbon dated to ca. 600 years ago, and a fish weir was recorded in the river channel immediately downstream of this site’s location. The predominant projectile points recovered at the site are Gunther-barbed, with other artifacts typical of the late prehistoric period also present, including more than 400 pottery sherds, many with twined basketry impressions. In addition to the extensive artifact assemblage, numerous faunal remains were recovered, including fish (salmon, chub, and suckers), deer, antelope, elk, mountain sheep, beaver, porcupine, small rodents, jackrabbit, cottontail, river otter, grizzly bear, mountain lion, and red fox (Mack 1983). An 1874 GLO plat map of Township 41 South, Range 5 West, suggests use of the area into the historic period.

Freedom Site (CA-SIS-1721). This pit house village site was excavated in 1994 and 1995 (Mack 1995 and 1996). An extensive assemblage of lithic materials was recovered from the site, including a variety of flaked stone tools, net sinkers, hopper mortar bases, hand stones, pestles, grinding slabs, and other ground stone tools. Also recovered were bone and antler tools, charred plant remains, a few sherds of very delicate pottery, and fragments of wooden house structural elements. Projectile points recovered by the excavations (including Gunther series, Desert Side-Notched, and Rose Spring Corner-Notched types) suggest a site occupation and use between 400 to 150 years B.P. (Mack 1996).

Iron Gate (CA-SIS-326). This late prehistoric village site along the Klamath River was excavated by the University of Oregon in 1960. The site was radiocarbon dated to ca. A.D. 1,400 to 1,600, with Gunther Barbed and Desert Side-Notched projectile points dominant. The excavation results included the reconstruction of a conical, bark-covered house measuring 5 to 6 meters in diameter, a size that is considered atypical for the ethnographically known Shasta, who occupied rectangular houses. Leonhardy concluded that rectangular houses were introduced sometime after 1,500 A.D. (Leonhardy 1967). The Iron Gate site probably is transitional between the central California and the Klamath Lakes/Columbia Plateau culture areas, with the California emphasis evidenced by the house form and the presence of hopper mortars (Leonhardy 1967).

The Klamath Basin is considered to be part of a region of overlapping or blending cultural traits from the California, Great Basin, and Plateau culture areas. Therefore, the following generalized overview draws upon information from each of the surrounding cultural areas. The chronology is organized by Paleoarchaic, Early Archaic, Middle Archaic, Late Archaic, and Late Prehistoric periods. Data specific to the Klamath River canyon supplements the overview where applicable. A generalization that can be made is that Klamath material culture tends to be more Plateau-like, while Shasta material culture is more inclined toward sharing patterns with the California cultures (Spier 1930).

6.3 Identifying Temporal Variability in Human Use of the Upper Klamath River Basin (Chronology)

Chronological studies are important to determine site-specific chronology, to compare and contrast occupational histories with other sites in surrounding areas, and to test the validity of current culture history sequences for the Klamath River region. Some chronological issues documented recently (Federal Energy Regulatory Commission 2007) are relevant for the present study, and are synthesized in this section. Chronological data are especially important for the study area prehistory because they may help determine the initial dates of Klamath and Modoc settlement and changes over time. Individual sites may not address these topics, but they can provide information relevant for local and regional syntheses.

Projectile Point Chronologies. Because various styles of projectile points were developed and used by Native Americans throughout the Holocene, they are useful as relative time markers. Archaeologists create regional projectile points typologies to assign these artifacts to particular periods of time. According to Rouse (1960), projectile points follow conceptual modes (ideas and standards which artisans expressed in the artifacts) and procedural modes (customs followed in making and using artifacts). These modes create inherent flaws in typological classification. The prehistoric "artisans" frequently altered a projectile point to facilitate tool reuse and maintenance, thus creating a danger of temporal assignments based on specific characteristics of surface observed artifacts or fragments (Flenniken and Raymond 1986).

Thomas (1986) contends that the potential for error does not result in diagnostic artifacts being useless as time markers. "Projectile points provide the single best way to monitor temporal change in the surface assemblages" of an area (Thomas 1986) and often they are the only source for making temporal assignments. In addition, projectile points also reflect subsistence practices. While projectile points can be used as hafted knives, others, by their very form, function best when thrust. Thus, projectile points may suggest site function (e.g., a hunting station, hosted hunters, or the location of hunting tool preparation).

Mack's projectile point typology for the Klamath Canyon is based on work in the Great Basin by Thomas (Mack 1991) and includes various attributes with relatively well-defined metric criteria and visually intuitive attributes. The Upper Klamath Canyon typology includes 30 individual point types and classes. Each point has a minimum of three measurement attributes, while most have four or more, including the visually intuitive attributes. The age estimates associated with each point style are not necessarily correlated with local radiocarbon dates; however, based on regional data, these point styles provide a relative age of site occupation.

For thrusting darts dating to the Early Archaic (Basin Phase), Beck suggests that the gradual shift from the combined use of corner-notched and side-notched points to the use of strictly corner-notched points reflects the technological superiority of corner-notching, which produces a point that is more resistant to breakage at the haft (Beck 1995). If observed variation in projectile point assemblages over time and space relate to function rather than style, the utility of projectile point chronology is reduced. A "long" chronology views gradual change and broad temporal ranges for individual point types. Conversely, Thomas (1981, 1986) takes a "short" chronology perspective, reflecting more reliance on style to indicate time.

In an attempt to "shorten" the chronology, Mack discusses problems with earlier Klamath Basin projectile point chronologies, particularly the Gunther Series, which she considers too broadly defined; the series covers about 2,000 years, or the entire period in which the bow and arrow was used. Mack makes a distinction in the Klamath Canyon projectile point typology between the Gunther Barbed and Gunther Stemmed points: Gunther Barbed appear to be more recent, while Gunther Stemmed seems slightly older (Mack 1991). Although not a "long" perspective, a more conservative one would be to accept Gunther as simply post-dating 2,000 B.P.

Radiocarbon Dating. Radiocarbon measurements always are reported in terms of years before present. This figure is based directly on the proportion of radiocarbon found in the sample. It is calculated on the assumption that the atmospheric radiocarbon concentration has always been the same as it was in 1950 and that the half-life of radiocarbon is 5,568 years. However, because the rate of production of radiocarbon in the earth's atmosphere is not constant, dating errors independent of statistics or laboratory procedures are caused by variations in the sun's magnetic field, and dates can vary as much as several hundred years. The general practice is to obtain four or more radiocarbon dates on a specific feature to identify the occurrence of the error. For radiocarbon dates to be accurately used as calendar ages, the dates must first be calibrated.

Tephrachronology. Trace element characterization uses microbe analysis to determine the source of volcanic glass shards found in sediments, which often can be linked to dated eruptions. In the Klamath Basin, the catastrophic eruption of Mt. Mazama (Crater Lake) had major impacts; while the eruption has not been specifically linked to the lowering of Lower Klamath Lake, this is possibly the case. The eruption probably temporarily "killed" the Klamath River and its tributaries by filling the drainage systems with pumice and silt and raising the water temperature. Not only would these cataclysmic events eliminate nearly all life within the river, the events certainly would have slowed down the reestablishment of stable salmon runs in the Klamath River watershed. Salmon require clear flowing drainages with clean gravel for successful spawning (Butler and Schalk 1986). Mazama ash has been radiocarbon dated in numerous contexts to 6,850 B.P. Thick layers of ash from the eruption covered nearly all of Oregon. A Mazama pumice lens is present within basal clays at Nightfire Island (Sampson 1985), and Mazama ash was identified at the Four Bulls site (35KL1459) (Wilson et al. 1996). For a complete listing of regional tephra layers derived from moderate to large eruptions during the late Pleistocene and Holocene, refer to the summary prepared by A. M. Sarna-Wojcicki et al. (1991).

Other Means of Dating Sites. Other dating techniques, such as inorganic carbon dating and measuring hydration rinds of obsidian artifacts, are considered less reliable than organic radiocarbon dating. Radiocarbon dates derived from freshwater shell often are much older—sometimes thousands of years older—than dates from other materials, such as charcoal, within the same deposit. For instance, age estimates often are corrupted when the shell is in proximity to limestone deposits or artesian springs (Federal Energy Regulatory Commission 2007). Still, shell dates are useful as an additional broad-scale age estimate for site use. Chatters' (1986) comparison of matched charcoal/shell dates in the Columbia Plateau suggests that shell and charcoal dates from the same contexts are statistically similar in the early to middle Holocene, but they diverge after about 5,000 B.P. For Chatters' study to apply to the Klamath Basin, shell and charcoal dates from the early to middle Holocene need to be examined (Wilson et al. 1996).

Radiocarbon dates were obtained from regional ceramic figurines from the Klamath Shoal midden site (Mack 1991). To date, ceramics in the Klamath Basin have not been the subject of intensive study. Regional ceramic studies in the Great Basin could provide baseline information upon which a Klamath Canyon ceramic tradition could be built. In the northern Great Basin, pottery is a late phenomena, thought to originate in the south, with the technology moving north within the last 500 years (Madsen 1986). In the Pacific Northwest, pottery is generally unknown. However, in the area defined by Mack (1990) from the Cascades of southern Oregon and northern California, pottery dates to approximately 1,100 to 350 B.P. and is generally not used for cooking but rather for serving food (Mack 1990). This is a separate pattern from Shoshone and other brownwares in the Great Basin and may suggest technological innovation in the Rogue, Klamath, and Pit River drainages distinct from Great Basin pottery use. X-ray fluorescence analysis has been effectively used to build on the chronological sequence in the Pit River region of northeast California (Cleland 1997). At the Four Bulls site, XRF analysis indicates continuity in the use of northeastern obsidian sources (especially Spodue Mountain) through time (Wilson et al. 1996). Since 1979, Mack has been compiling obsidian study results for the Upper Klamath River. XRF analysis has shown that the obsidian in the Upper

Klamath River Canyon comes from 11 distinct sources. The majority of the 207 sourced specimens come from the Medicine Lake Highlands, which are located 34 to 46 miles to the southwest (Mack 1997). Non-Medicine Lake Highlands sources include Spodue Mountain and Buck Mountain; the latter is located about 97 miles from the Klamath Basin. Preliminary age estimates suggest that Medicine Lake Highlands was the primary source of obsidian in the Upper Klamath River drainage before the Late Prehistoric period; however, finished obsidian tools from other sources were introduced in the Klamath Basin during the Late Prehistoric (Mack 1997).

Anthropologists study rock art to help understand the ritual and symbolic lives of the makers of the art. Reoccurring images or themes are often regarded as regional style and are used by anthropologists to make generalizations about the groups of people who occupied an area. Rock art studies in the Klamath Basin began with Julian Steward and Luther Cressman in the late 1920s and 1930s. Early writers stressed a Great Basin influence on regional rock art, while more recent studies have emphasized the similarity to Columbia Plateau rock art traditions (Ritter 1999). The Keno Pictograph site in the Upper Klamath River Canyon is considered to be of prehistoric age and part of the southern Plateau rock art tradition (Ritter 1999). Due to a number of factors, including site location and the style of art represented at the Keno Pictograph site, the Klamath/Modoc peoples are assumed to be the artists. A common form of rock art found in the Klamath River Canyon and throughout the Sierra Nevada is cupules or rain rocks. These shallow depressions pecked into boulders and other exposed rocks are considered to represent places of supplication for some desired effect, with each pit made as an accompaniment to an individual prayer. Repeated use may lead to entire surfaces of boulders that are covered with cupules, sometimes in circular or linear arrangements (Meighan 2000).

Research Topics Relevant to Chronology. Research topics relevant to the identification of temporal variability in human use of the Upper Klamath River Basin (chronology) include the following:

- What kinds of archaeological data are best suited to characterizing temporal variability?
- What is the nature of the relationship in stylistic variation of projectile points between those known from the study area and those known from the Upper Klamath River Basin and adjacent Lower Klamath and Great Basin regions?
- To what extent do archaeological data from the study area resolve the apparent differences among various chronological sequences?
- Is there evidence in the Upper Klamath River Basin of an extension of Basin Phase (circa 4,500 to 2,500 B.P.) artifacts and behavior, into the Canyon Phase (which begins around 2,500 B.P.) and through the three subphases until historic times?
- What is the nature of settlement and land use during the Basin Phase (a phase that generally lacks radiocarbon-dated sites from the Klamath Canyon [Mack 1991] and in the regions of south and central Oregon)?
- With respect to discovery and recordation of prehistoric sites, other relevant research questions include the following: What is the chronological range of occupation or use of each single-component, multi-component, or mixed-component site?

- Can distinct single-component loci be identified within multi-component sites? Can these loci be placed in chronological order using available data?
- Do the temporally diagnostic artifacts correlate with the absolute chronology (available through radiocarbon techniques, dendrochronology, etc.)?
- Is there evidence of demographic change (change in the group using a site, or evidence of change in a people's trade associations) through time in the artifact assemblages at villages or other sites?
- Do the temporally diagnostic artifacts correlate with the fortuitously visible or exposed site stratigraphy (as seen in cut banks, erosional profiles, or spoil from rodent burrows) to provide a rate of deposition and a determination of site integrity?
- Is occupation "continuous," or are distinct periods of disuse or abandonment present?
- Is the site chronology similar to other known sites in the region?
- Is a protohistoric component present?
- Do the obsidian data (sourcing and hydration) obtained from waste flakes and nondiagnostic artifacts produce a chronology? Are these data comparable to other data sets (such as diagnostic artifacts, obsidian sourcing and hydration of diagnostic artifacts, and radiocarbon samples)?
- Do the chronological data, particularly from obsidian hydration and radiocarbon dating, allow an assessment of the stratigraphic integrity of the site deposits?

Data sets required to address these chronological issues include the following:

- Stratigraphic information, which may include relative age estimates of landforms
- Radiocarbon age estimates (if later subsurface testing is conducted)
- Tephrachronology age estimates (if later subsurface testing is conducted)
- Stylistic variation in projectile points, pottery and/or other baked or fired clay objects and figurines, beads and ornaments of shell or bone, abraded and/or ground stone implements, and other time-sensitive artifacts (if present and observed and recorded).
- Stylistic variation in rock art may be chronologically ordered (relatively dated) using rock art dating techniques, including measurement of patinated (oxidized) surfaces on petroglyphs and accelerator mass spectrometry (AMS) radiocarbon (C-14) dating of organic paint pigments on pictographs.
- Functional variation is known to occur within a specific temporal range, such as that known for house types, basketry, or art. Because these dating techniques measure different events,

the age estimates derived from one may be used to evaluate the age estimates derived from another.

Identifying Variability in Lithic Technology in the Upper Klamath River Basin. Archaeological sites often retain little information other than their modern environmental setting and lithic artifact assemblage. Archaeologists must investigate lithic technology to place a site into a local or regional context. The study of the Upper Klamath Basin lithic technology has focused on determining the nature of flaked and ground stone procurement and manufacturing activities represented by both the artifacts and manufacturing waste. Lithic technology that produced flaked and ground stone artifacts has been studied through morphological inspection; raw material classification, sourcing, and frequency analysis; and a limited metric analysis of formal artifact types and debris. The raw material types were reviewed with respect to interpretations of aboriginal preference and local and regional trade networks. The artifact data to be collected were detailed in the field methods section of the work plan. Flaked stone assemblages from archaeological sites were divided into two main categories: worked flaked stone and debitage. Debitage is "residual lithic material resulting from tool manufacture [or maintenance]" (Crabtree 1982) and includes both unmodified flakes and shatter. Worked flaked stone includes objects from which flakes have been intentionally removed. These include flake tools, bifaces, projectile points, and cores. Flake tools include both expedient flake tools, used without formal edge modification, and formally retouched, heavily curated flake tools such as "thumbnail scrapers." Bifaces are flaked stone tools that have ventral and dorsal surfaces displaying overall surface modification through flake removal. Surface modification was not limited to edge treatment. Bifaces are often classified according to the five-stage scheme created by Errett Callahan (1979): Stage I is a minimally worked piece of stone with at least two (but typically very few) dorsal flake scars, while Stage V is a distinctly retouched, finished biface tool. Mack's (1991) knife typology includes nine distinct types defined by both metric measurements and intuitive attributes. Either method may be employed, with Callahan's focused on understanding the level of reduction of the tool (or tool preform), while Mack's system provides descriptive categories for the final tool only. Lithic debitage appears to be the largest class of artifacts to be anticipated. Methods of description for these artifacts can vary; methods should include descriptive attributes and emphasize debitage attribute data (i.e., platform type, dorsal cortex cover, dorsal flake scar count, size grade, raw material, etc.) that are relatively free of interobserver error (Carter and DeBoer 2002).

Ground stone, faunal, sediment, marine shell, and other materials should be classified by appropriate technological or descriptive manuals that allow for clear, concise, and repeatable classification of cultural artifacts and associated deposits (Dugas et al. 1995, Grayson 1973, Hughes and Bennyhoff 1986). With ground stone analyses, attributes of function relate to shape, use wear (number of facets and facet profile, outline, and measurement), use wear surface patterning and intensity, and artifact size (Dugas et al. 1995). Forms such as handstones, pestles, and abraders are anticipated, as are anvil stones (millingslabs and mortars) and shaped rock bowls, disks, and other objects. Recorded metric and morphological data allow for an approximation of ground stone function.

Research topics relevant to lithic technology include the following:

- What lithic assemblage(s) and manufacturing techniques (including types, range, and variability for both chipped and ground stone materials) are present?

- Do the lithic assemblage(s) and manufacturing techniques change through time?

- If chronological variation in lithic manufacturing techniques and raw material preference is present, do the metric and nonmetric (primary, secondary flakes, etc.) attributes of whole flakes change over time?
- Are lithic quarries or workshop and activity areas present, and do these change over time?

Data sets required to address lithic technology issues include the following:

- Comparative tabulations of lithic raw material types found at each site
- Recordation of lithic artifacts made from raw material of nonlocal origin
- Tabulations of lithic debitage platform, dorsal cortex cover, and dorsal flake scar count for at least a representative sample of these artifacts found at each site
- Metric and morphological recordation of formal artifact attributes

6.4 Distribution of Ethnic Groups, Precontact and Post-Contact

Accurate reconstruction of the precontact distribution of Native American ethnic groups is a task that has defied the best efforts of ethnographers and other researchers for more than a century. Identification of ethnic groups that lived in the study area can be achieved through archaeology and specialized subdisciplines.

Identifying the Prehistoric Distribution of Ethnic Groups. Important attributes of ethnic association can be expressed in ethnically diagnostic artifacts and rock art. For example, a distinctive muller is strongly associated with occupation or use by prehistoric and protohistoric Klamath Tribes. Ethnically diagnostic projectile points, beads and ornaments of shell or bone, pottery, or other implements and/or stylistically diagnostic artifacts can also be useful “ethnic signatures.” Obsidian procurement and exchange studies have advanced over the past few decades to enable archaeologists to recognize an ethnic signature by the frequency distribution/relative proportion of source-specific obsidian artifacts and debitage. Artifact inventories in the study area can be inspected and compared for the presence of “nonlocal” materials. Obsidian source analysis, if artifacts are collected, can be used in conjunction with hydration analysis to provide a chronological/location record of obsidian use at the sites. Debitage data can be reviewed for evidence of manufacturing for a surplus in excess of inferred local immediate needs. Hydration dates can be cross-checked against available absolute dates to assist in developing the chronological data to interpret the ethnic signature of any recognized trade patterns.

Ethnic association also can be viewed in rock art panels and the presence of certain design motifs that correlate to known cultural groups living in the area at the time of European contact. Ethnic signatures may also be recognized in house pit or other (spiral) rock alignments or structural remains.

Research topics relevant to ethnic distribution include the following:

- What materials indicative of trade are present?

- What is the point of origin of the "trade" commodities?
- How many obsidian sources are represented at each site?
- Do the obsidian sources change over time in terms of absence/preference and quantity? Can any changes be correlated with artifact style changes?
- Can any site be identified as a center for exchange or manufacturing of trade items or raw materials? How does the trade network represented at a site compare with other sites in the area?
- If protohistoric period sites can be identified, are any materials or sources unique to ethnic territories or cultural groups?
- Are any ethnically diagnostic artifacts present? If so, do they appear consistent with the function of the site where they are observed (e.g., a Klamath muller found in a village site or at a plant processing station), or do they appear to be anomalous (curated) trade goods seemingly functionally unrelated to the site?
- Are any ethnically diagnostic structures or features present?

Data sets required to address ethnicity issues include the following:

- Comparative tabulations of lithic raw material types found at each site
- Presence of local-, regional-, or foreign-origin culturally or ethnically diagnostic artifacts
- Presence of culturally or ethnically diagnostic rock art panels
- Recognition of distinctive house pit layout or geometry that may be culturally or temporally diagnostic.

Settlement Patterning. Klamath/Modoc "winter" villages were located along the shores of lakes, including Lower Klamath Lake, and streams, including Lost River, outside the study area. "Winter" is a misnomer, as many of these villages were occupied year-round and fishing continued through the winter months. The "winter lodges" consisted of semi-subterranean pit houses measuring from 12 to more than 35 feet in diameter and provided shelter for multiple families. The houses' central four-post frames were covered with planks and matting and then covered with earth (Stern 1998). Entrance into the pit houses was gained through a roof hatchway, which doubled as a smokehole. The Klamath/Modoc occupied spring settlements at semi-permanent camps during sucker fishing. Smaller mat lodges with side entrances or *wickiups*, some reaching diameters of 10 feet, provided shelter at these established camps (Stern 1998). Later in the season, the Klamath/Modoc peoples moved to the locations where wild parsley roots were dug. Summer movements were made for a number of gathering, fishing, and hunting activities. Additional moves were made to hunt at higher elevations in the fall. Small, portable *wickiups* were the main form of shelter during this time of the year.

Resource Use. Important resources for the Klamath/Modoc included sucker fish, waterfowl, and wild parsley roots. For the Klamath, fishing was a year-round activity; the Modoc focused their fishing on the seasonal fish runs (Stern 1998). A variety of fishing practices were employed, including dip nets, gill nets, spears, purse seines, A-frame nets plied from canoes or rafts, stone weirs, and angling with hook and line (Stern 1998). Other resources included various plant products, particularly camas and wocus, and deer, antelope, mountain sheep, and trout.

6.5 Identifying Resource Use (Subsistence) and Settlement Patterning

Settlement systems and accompanying subsistence strategies have been the topic of considerable interest in terms of regional research in northern California and southern Oregon. Settlement, subsistence, and seasonality studies are important in determining why and when sites were occupied (seasonally) and what economically valuable resources were used and/or exploited. The topics are functionally interrelated because the prehistoric people in the region were hunter/gatherers who relied on available seasonal resources and scheduled their subsistence in response to resource availability.

Subsistence and settlement patterns can be discerned from careful examination of the archaeological sites that reflect past use of the area. Site types expected to be present include major village sites, short-duration campsites, sites used for special resource procurement or processing of vegetal or faunal resources (fishing and/or fish processing, drying, and smoking stations, plant gathering/processing stations such as bedrock mortar complexes, and hunting and meat butchering camps), raw material quarry sites (for the acquisition and initial reduction of suitable tool stone), food or equipment storage sites (talus storage pits, dry rock shelters and caves, acorn granaries and storage pits), rock art and/or ceremonial or religious sites (pictograph and/or petroglyph panels, rain rocks, and baby rocks), burials and cemeteries (and cremation sites), and structures or former structures (rock walls, hunting blinds, cairns and piles, fish weirs, house pits, sudatories or sweathouses, cooking hearths or smoking racks, rock rings/sleeping circles/temporary brush shelter support circles, and rock spirals and other geoglyphs). The expected site types and the observed artifactual evidence can contribute information about prehistoric subsistence and settlement patterns.

Research topics relevant to subsistence and settlement include the following:

- In light of previous work in the area, how do the artifact assemblages observable on the surface of the archaeological sites represent subsistence and settlement?
- What is the functional variability among archaeological assemblages relative to the distribution of prehistoric cultural resources?
- What was the subsistence economy at the sites in the study area and did it change through time?
- Does the subsistence regime correlate with a specific season or seasons?
- Can the subsistence activities be correlated with specific intra-site locations?

- Can a specific season or seasonal round be determined from the range of subsistence activities represented at sites in the Klamath Basin?
- How are the various site types distributed across the study area landscape? Does site type distribution illustrate specific settlement patterns or systems?
- If macroscale mobility is indicated, is this correlated with climatic change?
- What are the predominant faunal and vegetal resources associated with the archaeological sites? Can their ecological zones be determined? Are there changes in species exploitation over time?
- Do the results of previous faunal, palynological, and macrobotanical studies suggest substantive differences in resource exploitation among different site types? Does the discovered site show evidence of deposits capable of yielding faunal or other macro/microfossil remains?
- Do the results of the paleoenvironmental studies indicate relationships among the populations of the various sites (that is, macroscale mobility on a seasonal, annual, or multiannual basis)?
- Are faunal/botanical remains present?
- Can subsistence activities be correlated with specific cultural groups? Are the subsistence activities specific to certain areas? Do the subsistence activities fluctuate through time and space?

Data sets required to address these settlement and subsistence issues include the following:

- Correlation of site location with important subsistence resources (fish, economically important plants, upland game trails, etc.) to help determine site type and function and the role of the site in the local settlement system
- Inventory of observable artifacts and features that reveal site type and function and the role of the site in the local subsistence and settlement system(s)
- Correlation of site location with information provided from tribal oral history studies to reveal site type and function and the role of the site in the local subsistence and settlement system(s)
- Inventory of observable ecofacts (such as faunal remains, rocks foreign to a site but not culturally modified, etc.) that reveal site type and function of the site in the local subsistence system

Data sets required to address subsistence, settlement, and seasonality research questions require observation and recordation of ecofactual and artifactual remains present at each site. These data can be used to examine patterns of transhumance (seasonal movements of peoples related to subsistence practices), gathering and hunting behavior, and site placement with respect to local resources.

A subsistence framework can be constructed using any available faunal, macrobotanical (seeds, stems, leaf parts, etc.), and paleoenvironmental data. Comparisons can be made against the available ethnographic record. Attempts to determine seasonality can be made through the analysis of the faunal and macrobotanical information.

Settlement patterns can be analyzed by examining site placement and spatial patterns of seasonally dependent cultural remains among different sites. Specialized data collection, if undertaken in conjunction with subsurface testing, can yield faunal, palynological, and macrobotanical samples. In addition, the evaluation of certain artifact types (projectile points, bifaces, ground stone, etc.) may provide data for inferences on the subsistence practices and seasonality of sites by the prehistoric inhabitants of the area. The faunal analysis, if conducted, can provide qualitative and quantitative summaries of the archaeofaunal assemblage.

Interpretations of hunting behavior, food processing, seasonality, and paleoenvironmental life zone reconstruction may result from the analysis. Faunal analysis may also provide information on intra-site task differentiation by comparing the frequencies of the relative minimum number of individuals (MNI) and number of individual species present (NISP) in contingency arrays and by measuring the association and dependence between taxonomic categories and spatial location.

6.6 Identifying Prehistoric Site Function and Organization by Site Type

Sites, whether single, multi-component, or mixed, are microcosms of cultural activities and use. Sites come into existence for a variety of reasons but are generally related to sociodemographic and ceremonial/religious purposes (including settlement, subsistence, and economics). Interpretation of site function relies on the type, amount, and arrangement of cultural material observed and available for analysis and comparison by cultural resource specialists and knowledgeable sovereign diplomats.

Archaeological material may be arranged in clusters (associations) or dispersed vertically or horizontally throughout a site. These arrangements allow the identification of activity areas or loci.

Research topics relevant to site function and organization include the following:

- What is the function(s) of each site? What activities were conducted? Can multiple use or functions be identified?
- Does the site belong to a specific physiographic area (that is, correlation of site type with geographical area) or geological area? (For example, are village sites confined to riparian or marsh areas?)
- Can the site be placed into a regional network? (For example, allowing for resource availability and environmental factors, lithic scatters and temporary camps should be interrelated and located within a geographically restricted zone.)

The interpretation of site function and functional significance depends on the interpretation of the kind and context of cultural materials found at each site. Any activity loci at each site should be identified on the basis of the interpretation of individual artifacts and assemblages, as well as other factors.

The majority of the recorded prehistoric site types include the following:

- Lithic scatters
- "Habitation debris" (for example, temporary camp, seasonal base camp, permanent village, or permanent/seasonal village)
- Bedrock mortars or other milling features (such as groundstone)
- Rock art and/or spiral rock alignment or stacked rock sites
- Lithic quarry/source
- Burial/cremation grounds, cemeteries, or isolates

Site types that do not fit these categories may exist and should be classified based on their recorded patterns. These may include cultural heritage (e.g., Traditional Cultural Properties) sites such as resource gathering places, places of legendary and important historical events, or spiritual sites such as power places (rain rocks, springs, and others), sweat places, and religious event places.

The use of the site as the basic analytical unit has the potential to yield data on the following:

- Settlement patterns
- Subsistence patterns
- Economic pursuits
- House construction and use
- Lithic technology
- Chronology
- Domestic organization and practices
- Floral and faunal communities
- Paleoenvironments
- Physiography and geomorphology
- Geochronology, sedimentation, and stratigraphy

Previous research domains have identified several data requirements that have implications for interpretations of site function and classification of site type. Two data sources (obsidian hydration and lithic tool wear pattern analyses) are useful. Obsidian hydration dates may help identify components at sites in the study area. Single component sites reflect a single use. Two-component sites, representing two similar or different activities or events in time and space, are more difficult to interpret than single-component sites; as a result, only general function or chronological placement may be possible from the data obtained.

Multi-component sites, representing three or more similar or different activities or events through time and space, are subject to the same restrictions on interpretation as two-component sites. Mixed-component sites have a wide range of hydration readings from both surface and subsurface contexts, indicating disturbance and lack of integrity.

Wear pattern analysis can be a useful means of determining the function(s) of formed tools and unmodified debitage. In addition to sample size, edge damage caused by frost heaving, cattle trampling, abrasion from the site matrix, and numerous other factors (including the brittle nature of obsidian) suggests that wear pattern analysis of either artifacts or debitage from the sites would be inconclusive.

Spiritual Practices. Spiritual practices of the Klamath River tribes have been based on the concept of spiritual or supernatural power that permeates the environment (including the weather, rocks, springs, trees, and animals) and that is mediated by a shaman (Theodoratus et al. 1990). Legends explain the relationships of the powers and human beings. Spiritual practices vary and often incorporate special spaces believed to hold supernatural qualities, including topographic features in remote settings. These places have been used in spirit quests to obtain special powers.

Certain plants thought to posses supernatural qualities have been used in curing ceremonies. The local American Indians (Klamath/Modoc and Shasta groups) used hot springs along the Klamath River and also cremated and/or buried the dead near the river. Areas where human remains have been deposited, including burials, cremation grounds, and cemeteries, are places of special traditional use that are to be cared for and protected from disturbance.

The appearance of non-native colonialists and settlers in the Klamath Basin greatly disrupted Indian groups, killing large numbers of people through introduced diseases, dislocating those who lived, introducing new technology, and eventually forbidding the practice of native religious practices and language in non-Indian schools. One reaction to the dislocations was the adoption of revitalization movements, such as the Ghost Dance of 1870 (Hagan 1988).

6.7 Summary of Relevant Cultural Resources

Clear Lake National Wildlife Refuge. To date, archived cultural resources known to be within the congressionally authorized boundaries of the Clear Lake NWR consist of 11 recorded prehistoric sites (i.e., worked stone, stacked rocks, cleared areas, bedrock mortar) and 1 recorded historic site (i.e., rock enclosure). Although the area on and around the Clear Lake NWR was used extensively by Native Americans, and there are an abundance of cultural resource sites, there have not yet been any nominated for inclusion onto the NRHP.

Tule Lake National Wildlife Refuge. To date, archived cultural resources known to be within one mile of the congressionally authorized boundaries of the Tule Lake NWR consist of 57 recorded prehistoric sites (i.e., habitation sites, rock shelters, human remains, pictographs, midden, worked stone, stacked rock, bedrock mortars, house pits, ground stone, traditional use locus, cleared areas) and 12 recorded historic sites (i.e., structural remains, refuse scatter, battlefields, repatriation locus, C.C.C. activity loci, Tule Lake Segregation Center). Although the area on and around Tule Lake was used extensively by Native Americans and there is an abundance of cultural resource sites, only one site has thus far been determined eligible for the NRHP, the Tule Lake Segregation Center. The Tule Lake Segregation Center is unique because it became the largest of the ten WRA camps and because it was used to detain those labeled as “disloyal.” It was designated a National Historic Landmark in

February 2006 because of its national importance in the historic context of Japanese Americans in World War II (National Park Service 2006, Kameda 2010). In December 2008, this site was declared a National Monument by Presidential Proclamation (Kameda 2010).

Bear Valley National Wildlife Refuge. To date, no archived cultural resources are known to be within the congressionally authorized boundaries of the Bear Valley NWR.

Lower Klamath National Wildlife Refuge. Lower Klamath NWR is currently listed on the NRHP as an Historic District which recognizes it as an early example of an American attempt at preservation of natural wetlands and wildlife for the future. There are numerous archaeological sites on the Lower Klamath NWR, which is located in both rural northeastern California and southern Oregon. To date, archived cultural resources known to be within the congressionally authorized boundaries of the Lower Klamath NWR consist of 44 recorded prehistoric sites (i.e., worked stone, habitation sites, human remains, groundstone, traditional use locus, bedrock mortars) and 14 recorded historic sites (i.e., historic debris scatters, one NRHP District contributing site, 10 NRHP District contributing structures). Although the area on and around the Klamath Marsh was used extensively by Native Americans and there is an abundance of prehistoric cultural resource sites, none have thus far been nominated for inclusion onto the NRHP.

7. References

Access Genealogy.com

2010aOregon Indian Tribes website available at: http://www.accessgenealogy.com/native/oregon/modochist.htm. Accessed November 26, 2010.

2010b Indian Tribal History website available at: http://www.accessgenealogy.com/native/tribes/indiantribehistory7.htm#Yahuskin. Accessed November 26, 2010.

Aikens, C. Melvin

1993 Archaeology of Oregon. U.S. Department of the Interior, Bureau of Land Management.

Aikens, C. Melvin, and Dennis L. Jenkins (editors)

1994 "Archaeological Research in the Northern Great Basin: Fort Rock Archaeology Since Cressman." University of Oregon Anthropological Papers 50. Eugene.

Aikens, C. Melvin, and Rick Minor

1978 "Obsidian Hydration Dates for Klamath Prehistory." Tebiwa: Miscellaneous Papers of the Idaho State University Museum 11. Pocatello.

Ames, K.M., D.E. Dumond, J.R. Galm, and R. Minor

1998 "Prehistory of the Southern Plateau." Handbook of North American Indians, Volume 12: Plateau. edited by Deward E. Walker, Jr., pp. 103-119. W.C. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Ames, Kenneth L., and Herbert D.G. Maschner

1999 Peoples of the Northwest Coast: Their Archaeology and Prehistory. Thames and Hudson, London.

Antevs, Ernst

1955 "Geologic-climatic Dating in the West." American Antiquity 20(4):317-335.

Anonymous

1947 Upper Klamath Lake Boating. Oregon Historical Quarterly. Vol. 48, No. 1. Oregon Historical Society. Portland, Oregon.

Applegate-Good, Rachael

1941 Early Transportation. Klamath Echoes. 1:2. 1965. Klamath County Historical Society.

Barrett, S.

1910 "The Material Culture of the Klamath and Modoc Indians of Northeastern California and Southern Oregon". University of California Publications in American Archaeology and Ethnology. 5(4):239-292.

Beck, Charlotte

1995 "Functional Attributes and the Differential Persistence of Great Basin Dart Forms." Journal of California and Great Basin Archaeology. 17(2):222-243.

Beck, W., and Y. Haase

1974 *Historical Atlas of California*. University of Oklahoma Press, Norman, Oklahoma.

Bowden, Jack

2002 Land, Lumber Companies and Mills in the Klamath Basin: 1864-1950. Theme issue "The Timber Industry in the Klamath Basin," Shaw Historical Library. 16: 5-41.

Bradbury, J. Platt, Steven M. Colman, and Richard L. Reynolds.

2004 The history of recent limnological changes and human impact on Upper Klamath Lake, Oregon. Journal of Paleolimnology 31: 151–165. Kluwer Academic Publishers. Netherlands.

Butler, V.L., and R.F. Schalk

1986 Holocene Salmonid Resources of the Upper Columbia. Institute for Environmental Studies, Office of Public Archaeology, University of Washington, Seattle.

Caldwell, W. W. and Carlson, R. L.

1954 "Further Documentation of 'Stone Piling' during the Plateau Vision Quest". American Anthropologist. 56: 441–442.

Callahan, Errett

1979 "The Basics of Biface Knapping in the Eastern Fluted Point Tradition: A Manual for Flintknappers and Lithic Analysts". Archaeology of Eastern North America, Volume 7. Braun-Brumfield Inc. Ann Arbor, Michigan.

Carlson, R. L.

1959 "Klamath Henwas and Other Stone Sculpture". American Anthropologist. 61: 88–96.

Carter, James A., and Trent DeBoer

2002 Results of a Cultural Resources Inventory of the Yakima Training Center, Yakima and Kitittas Counties, Washington. report prepared for the U.S. Army, Ft. Lewis, by Historical Research Associates, Inc., Seattle.

Chartkoff, Joseph L., and Kerry K. Chartkoff

1984 The Archaeology of California. Stanford University Press. Stanford, California.

Chatters, James C.

1986 "A Deductive Approach." Archaeological Predictive Modeling: The Yakima Firing Center (Part II), by W.C. Smith and J.C. Chatters. A draft report prepared for the U.S. Army, Fort Lewis, by Central Washington University Archaeological Survey, Geographic Information Systems Laboratory, Ellensburg.

Cheatham, R.

1991 Archaeological Investigations at the Williamson River Bridge Site (35KL677): A Riverside Fishing Camp in Klamath County, Oregon. Oregon State Museum of Anthropology Report 91-7. University of Oregon, Eugene.

Cleland, James H.
1997 Prehistory of the Middle Pit River, Northeastern California: Archaeological Investigations at Lake Britton, Pit 3, 4 & 5. Report prepared for Pacific Gas and Electric Company, San Francisco by KEA Environmental Inc., San Diego, and Dames & Moore, Inc., Chico, California.

Clifton, James A and David Levine.
1963 Klamath personalities: ten Rorschach case studies. University of Kansas, Department of Sociology and Anthropology, Lawrence, Kansas.

Conway, F.D.L., and G.E. Wells
1994 Timber in Oregon: History and Projected Trends website available at http://www.icecubetopper.com/pdfs/docs/or/or_su/pdfs/EM8544.pdf. Accessed April 13, 2010.

Coville, Frederick V.
1904 *Wokas*, a primitive food of the Klamath Indians. In Annual Report for the U.S. National Museum for 1902. 725–39. U.S. National Museum. Washington, D.C.

Crabtree, Don E.
1982 An Introduction to Flintworking (second edition). Occasional Papers of the Idaho Museum of Natural History No. 28. Pocatello.

Cressman, Luther S.
1956 "Klamath Prehistory." American Philosophical Society Transactions, New Series 46(4). The American Philosophical Society, Philadelphia, Pennsylvania

Daniels, Roger
2002 "Incarceration of the Japanese Americans: A Sixty-Year Perspective," *The History Teacher* May 2002 <http://www.historycooperative.org/journals/ht/35.3/daniels.html> (8 Dec. 2010).

Donnelly, Robert
2003a George Nurse, Founder of Linkville. Oregon Historical Society website available at http://www.ohs.org/education/oregonhistory/historical_records/dspDocument.cfm?doc_ID=13FDAEE2-0D8E-8F59-72C579404331FE76. Accessed December 26, 2007.

Donnelly, Robert
2003b Weyerhaeuser Timber Company website available at http://www.ohs.org/education/oregonhistory/historical_records/dspDocument.cfm?doc_ID=1422349B-EB1B-2C4D-9BEC2AE87F1A31B6. Accessed April 13, 2010.

Dugas, Daniel P., Kathryn Ataman, Margaret Bullock, and Robert G. Elston
1995 Archaeological *Investigations at Tosawihi, A Great Basin Quarry, Part 7, 26Ek5040: A Middle Archaic Reduction Station and Campsite*. Prepared for Bureau of Land Management, Elko Resource Area, Elko, Nevada, on behalf of Newmont Exploration. Ltd., Carlin, Nevada.

Evening Herald
1917 Midnight Fire Stuns City. The Klamath Falls Evening Herald, July 16.

Fagan, J.L., D.C. Wilson, T.J. Hills, S. Hess, J. Wollin, E.E. Forgeng
1994 Cultural Resources Inventory and Site Testing Plans for the Proposed Pacific Gas Transmission Company's Medford Extension, Volume 1. Prepared for CH2M HILL, Corvallis, Oregon, and Pacific Gas Transmission Company, Sacramento, California, by Archaeological Investigations Northwest, Inc.

Federal Energy Regulatory Commission
2007 *Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project FERC Project No. 2082-027*. Oregon and California Federal Energy Regulatory Commission Office of Energy Projects Division of Hydropower Licensing. Washington, DC.

Flenniken, J. Jeffery, and Anan W. Raymond
1986 "Morphological Projectile Point Typology: Replication, Experimentation, and Technological Analysis." American Antiquity 51(3):603-614.

Forest Community Research
2002 Assessment of the Northwest Economic Adjustment, Klamath Falls, Klamath County Oregon, by Grace M. Zilverberg website available at http://www.sierrainstitute.us/neai/NEAIAssessment.html. Accessed April 23, 2010.

Gatschet, Albert S.
1890 "The Klamath Indians of Southwestern Oregon." Contributions to North American Ethnology 2 (1-2). U.S. Geographical and Geological Survey of the Rocky Mountain Region, Washington.

Gleason, Susan Marie.
2001 In Search of the Intangible: Geophyte Use and Management Along the Upper Klamath River Canyon. Ph.D. dissertation, Department of Anthropology, University of California, Riverside.

Grayson, Donald K.
1973 "On the Methodology of Faunal Analysis". American Antiquity. 38(4):432–439.

Hagan, William T.
1988 "United States Indian Policies, 1860-1900." History of Indian-White Relations. edited by Wilcomb E. Washburn. pp. 51-65. Handbook of North American Indians, vol. 4. W.C. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Hannon, N., and R.K. Olmo (editors).
1990 Proceedings of the 1989 Symposium on the Prehistory of Southwest Oregon. Medford, Oregon.

Heizer, Robert F.
1942 "Massacre Lake Cave, Tule Lake Cave, and Shore Sites." L.S. Cressman, Archaeological Researches in the Northern Great Basin: 121-134. Washington, D.C.: Carnegie Institution of Washington Publications 538.

Helfrich, Devere
1965 "As told to me …by Judge U. E. Reeder, March 3, 1948". Klamath Echoes. 1:2. Klamath County Historical Society.

1977 “Midland” Klamath Echoes. 15. Klamath County Historical Society.

Herald and News
1999 The 1900s: A Century of news in the Klamath Basin. December 31. Klamath Falls, Oregon. Available at Klamath County Museum, Klamath Falls, Oregon.

History San José
2010 Cannery Life, Del Monte in the Santa Clara Valley. website available at http://www.historysanjose.org/cannerylife/through-the-years/1917-1966/cal-pak/index.html. Accessed November 26, 2010.

Hughes, Robert E., and James A. Bennyhoff
1986 “Early Trade.” Handbook of North American Indians, Volume 11: Great Basin. edited by W. L. d’Azevedo, pp. 238-255. Smithsonian Institution, Washington, D.C. Kameda, Tadashi, Knowledgeable Local Historian. November 4, 2010 – discussion with Patrick Brunmeier, Anthropologist, North State Resources, Inc.

Kroeber, A. L.
1916 “Inheritance by Magic”. American Anthroplogist. v.18:19-40.

Kroeber, Alfred L.
1953 The Modoc. in The Handbook of the Indians of California. California Book Co., Berkeley, California. (Reprint of Bulletin 78 of the Bureau of American Ethnology, 1925)

Lamm, W.E.
1944 Lumbering in Klamath. Modoc Point, Oregon.

Leonhardy, Frank C.
1967 The Archaeology of a Late Prehistoric Village in Northwestern California. University of Oregon Museum of Natural History Bulletin No. 4. Eugene.

Mack, Joanne M.
1983 *Archaeological Investigations in the Salt Cave Locality: Subsistence Uniformity and Cultural Diversity on the Klamath River, Oregon.* University of Oregon Anthropological Papers 29. Eugene.

1989 Archaeology of the Upper Klamath River. Department of Sociology and Anthropology, Pomona College, Pomona, California.

1990 “Ceramic Figurines of the Western Cascades of Southern Oregon and Northern California.” New World Figurine Project, Vol 1. Research Press. Provo. Utah.

1991 “Klamath River Canyon Prehistory.” Klamath Canyon Prehistory and Ethnology. edited by Richard Hanes. USDI BLM, Oregon State Office, Cultural Resource Series No. 8. Portland, Oregon.

1995 Preliminary Report on the Upper Klamath River Canyon Project: Summer of 1994 Archaeological Testing, Site Evaluation Report, Historical Overview, and Ethnobotanical Report. Prepared for U.S. Department of Interior, Bureau of Land Management, Lakeview District, Klamath Falls Resource Area, Klamath Falls Oregon.

1996 Preliminary Report on the Upper Klamath River Canyon Project: Summer of 1995 Archaeological Testing Report on A-SIS-1198 and A-SIS-1721, Site Evaluation Report, and Ethnobotanical Report. Prepared for U.S. Department of Interior, Bureau of Land Management, Ukiah District, Redding Resource Area, Redding, California.

1997 Upper Klamath River Obsidian Studies paper presented at the State of Jefferson 21st Annual Meeting. Medford, Oregon. March 7, 1997.

Madsen, David B.
1986 "Prehistoric Ceramics." Handbook of North American Indians, Volume 11: Great Basin. Edited by Warren L. D'Azevedo, pp. 206-214. W. C. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Martin, Marlene M.
2006 Klamath Culture Summary, Center for Social Anthropology and Computing Ethnographics Gallery, University of Kent, Canterbury, England website available at (http://lucy.ukc.ac.uk/ethnoatlas/hmar/cult_dir/culture.7853), visited November 27, 2010.

Meighan, Clement W.
2000 Rock Art on the Channel Islands of California. Pacific Coast Archaeological Society Quarterly 36(2):15-29.

Moore, Jeff
2010 Oregon, California & Eastern Railroad: Weyerhaeuser Woods Railroad website available at http://www.trainweb.org/highdesertrails/oce.html. Accessed April 11, 2010.

Moratto, Michael J.
1984 California Archaeology. Academic Press, Orlando, Florida.

Most, Stephen.
2003 The Oregon History Project: Nature and History in the Klamath Basin. Oregon Historical Society. website available at http://www.ohs.org/education/oregonhistory/narratives/index.cfm?nar_ID=369E6896-E9A8-F152-438ED3A35A74B209. Accessed November 26, 2010.

National Park Service.
2001 A Brief History of the Modoc War. brochure available at Lava Beds National Monument, California.

2006 Tule Lake Segregation Center-- National Register's Asian-Pacific American Heritage Month Feature. National Historic Landmarks Collection. U.S. Department of Interior. Washington, D.C.

Nilsson, K.M.
1985 Artifact variation as a measure of Cultural Affinity: A Study of Surface Lithic Assemblages from Shasta and Modoc Indian Territories, California unpublished Master's thesis, Department of Anthropology, California State University, Los Angeles.

Oetting, Albert C.

1993 An Archaeological Survey along Line 19, a Pacific Power & Light Company 115 kV Transmission Line between the Klamath River, California, and the Rogue River. Report No. 149 prepared by Heritage Research Associates for Pacific Power and Light Company.

1996 Archaeological Inventory and Evaluation of the Orwick BLM Land Exchange Parcels, Siskiyou County, California. report prepared by Heritage Research Associates, Eugene, Oregon.

Portland State University History Dept.

2001 Roads and Trails in Oregon, 1848-1930: A Historical Context Document for the Bureau of Land Management. *ms available at:* http://www.oregon.gov/OPRD/HCD/OHC/docs/klamath_highway_context.pdf?ga=t

Rajala, Richard A.

1989 Bill and the Boss: Labor Protest, Technological Change, and the Transformation of the West Coast Logging Camp, 1890-1930. Journal of Forest History 33(4): 168-179.

Raven, Christopher.

1984 “Northeastern California.” California Archaeology, by Michael J. Moratto, pp. 431-469. Academic Press, Orlando. Florida.

Ritter, Eric W.

1989 Sheep Rock Shelter (CA-SIS-266): Archaeological Test Excavations in Shasta Valley. report on file at the Bureau of Land Management, Redding, California.

1999 “Boundary, Style and Function: Extrapolations from the Keno, Oregon Pictographs.” American Indian Rock Art, Vol. 25. edited by Steven M. Freers, pp. 81-100. American Rock Art Research Association.

Rouse, Irving.

1960 “The Classification of Artifacts in Archaeology.” American Antiquity. 25:313-323.

Sampson, C. Garth.

1985 “Nightfire Island: Later Holocene Lakemarsh Adaptation on the Western Edge of the Great Basin.” University of Oregon Anthropological Papers 33. Eugene.

Sarna-Wojcicki, A. M., K. R. Lajoie, C. E. Meyer, D. P. Adam, and H. J. Rieck.

1991 “Tephrochronologic Correlation of Upper Neogene Sediments along the Pacific Margin, Conterminous United States.” The Geology of North America, Volume K-2, Quaternary Non-Glacial Geology: Conterminous United States. edited by R. B. Morrison, pp. 117-140. Geological Society of America, Boulder, Colorado.

Shaver, F.A., Arthur P. Rose, R. F. Steele & A. E. Adams.

1905 An Illustrated History of Central Oregon” (“Embracing Wasco, Sherman, Gilliam, Wheeler, Crook, Lake, & Klamath Counties”). Western Historical Publishing Co., Spokane, Washington.

Siskin, B., J. Lang, B. Texier, C. DeBaker, and A. McCarthy Reid
2009 Cultural resources inventory and evaluation for the Kilarc-Cow Creek Hydroelectric Decommissioning Project, FERC No. 606, Shasta County, California. Prepared for Pacific Gas and Electric Company. Garcia and Associates, San Anselmo, California.

Siskiyou County Board of Supervisors District Five
2010 Indian Matters on the Upper Klamath website available at http://users.sisqtel.net/armstrng/Indupper_klamath.htm. visited November 28, 2010.

Spencer, Robert F.
1952 "Native Myth and Modem Religion Among the Klamath Indians". Journal of American Folk-Lore. 65(257);217-225.

Spier, Leslie.
1930 Klamath Ethnography. University of California Publications in American Archaeology and Ethnology 30. University of California Press, Berkeley.

Stern, Theodore.
1965 The Klamath tribe; a people and their reservation. Seattle, University of Washington Press, [c. 1966].

1998 "Klamath and Modoc." Handbook of North American Indians, Volume 12: Plateau. edited by Deward E. Walker, Jr., pp. 446-466. W.C. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Stone, Buena Cobb.
1990 Old Fort Klamath, an Oregon Frontier Post, 1863-1890. Webb Research Group Publishers. Medford, Oregon.

Tasa, Guy L., and Thomas J. Connolly
1997 Archaeological Recovery and Reburial at the Klamath River Bridge Cemetery Site (35KL1121). OSMA Report 97-2, State Museum of Anthropology, University of Oregon.Theodoratus, D.J., M.M. Ashman, H. McCarthy, and D.L. Genetti.

1990 Klamath River Canyon Ethnology Study. prepared by Theodoratus Cultural Research, Inc. for BioSystems Analysis, Inc. under Contract No. OR110-PH9-5038, United States Department of the Interior Bureau of Land Management, Lakeview District Office, Lakeview, Oregon.

Thomas, David H.
1981 "How to Classify the Projectile Points of Monitor Valley, Nevada." Journal of California and Great Basin Anthropology 3(1):7-43.

1986 "Points on Points: A Reply to Flenniken and Raymond." American Antiquity 51(3):619-627.

Tonsfeldt, Ward
1990 Historical Resource Survey, Rural Klamath County, Oregon website available at http://www.oregon.gov/OPRD/HCD/OHC/docs/klamath_klamathcounty_context.pdf. Accessed April 12, 2020.

U.S. Fish and Wildlife Service

1998 Environmental Assessment for an integrated pest management program for leased lands at Lower Klamath and Tule Lake National Wildlife Refuges, Oregon/California. Prepared for U.S. Bureau of Reclamation and Fish and Wildl. Ser. under Contract No. 14-48-0001-94067(TS).

2001 Implementation of the Agricultural Program on Tule Lake National Wildlife Refuge Klamath Basin National Wildlife Refuge Complex Draft Environmental Assessment. ms on file at: Klamath Basin National Wildlife Refuge Complex, Tulelake California.

2010a Klamath Basin National Wildlife Refuge Complex: Refuge History. Fish and Wildlife Service, Pacific Southwest Region website. Available at: http://www.fws.gov/klamathbasinrefuges/history.html.

2010b Klamath Basin National Wildlife Refuges Planning Update #1/Spring 2010 Fish and Wildlife Service Klamath Basin National Wildlife Refuges, Tulelake, California).

Weddell, B.J., K.L. Gray, J.D. Foster. 1998. History and Ecology of Lower Klamath, Tule Lake, Upper Klamath, and Klamath Forest National Wildlife Refuges, Oregon and California. Prepared for USDI Department of the Interior Fish and Wildlife Service Portland, Oregon. Draft February 17, 1998.

Wilson, Douglas C., Terry L. Ozbun, Julia J. Wilt, and Judith S. Chapman.

1996 Volume 1: Expanding the Archaeology of the Klamath Basin and Cascade Range of Southern Oregon. PGT Project Report # 19. Results of Treatment of Cultural Resources in Pacific Gas Transmission Company's Medford Extension Pipeline Project. Archaeological Investigations Northwest, Inc. report # 114, prepared for Pacific Gas Transmission Company, Portland, Oregon.

Zilverberg, Grace M.

2002 Klamath Falls, Klamath County, Oregon. in Northwest Economic Adjustment Initiative Assessment website available at http://www.sierrainstitute.us/neai/OR_case_studies/Klamath_Falls_OR.pdf. Accessed April 12, 2010.

Appendix P – Economic Analysis of Klamath Basin National Wildlife Refuge Complex Comprehensive Conservation Plan Alternatives

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Draft Economic Analysis
Klamath Basin National Wildlife Refuge Complex
Comprehensive Conservation Plan

Division of Economics
U.S. Fish and Wildlife Service

Assistance from:

TCW Economics
and
North State Resources, Inc.

April 27, 2016

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Introduction

The Klamath Basin National Wildlife Refuge Complex (NWRC) consists of six national wildlife refuges (NWRs) located in northern California and southern Oregon. Five of the six NWRs, including Lower Klamath, Clear Lake, Tule Lake, Bear Valley, and Upper Klamath, are the focus of this economic assessment and span three contiguous counties, including Siskiyou and Modoc Counties in northern California and Klamath County in southern Oregon. This three-county area is hereafter referred to as the study area for this economic assessment.

The assessment evaluates the current economic contribution of the five refuges and potential economic effects resulting from implementing alternative CCP management actions that are part of a Comprehensive Conservation Plan (CCP) being developed by the U.S. Fish and Wildlife Service (Service). The CCP provides a description of the desired future conditions and long-range guidance to accomplish the purposes for which the refuges were established. The CCP and accompanying Environmental Impact Statement (EIS) address Service legal mandates, policies, goals, and National Environmental Policy Act (NEPA) compliance. This economic analysis was conducted to assist the Service with completing the CCP/EIS document for the five refuges in accordance with NEPA.

Economic effects addressed in this analysis include those associated with budget expenditures and public use of the refuges, and agricultural production on some refuge lands. The refuge administration budgets were apportioned from the overall Klamath Basin NWRC according to historical and expected use or resources. Expenditures associated with managing a sixth refuge (the Klamath Marsh NWR) are not analyzed in this study. No economic benefits or effects are expected on the Klamath Marsh NWR from implementing any of the alternatives herein.

Methodology

The Service is evaluating several alternatives for managing the five Klamath Basin NWRC refuges that are included in this analysis. (The number of alternatives varies for each refuge.) Additionally the alternatives within each refuge are independent. For example Clear Lake NWR could choose Alternative A (No Action) while Bear Lake NWR could implement Alternative B. Each alternative includes numerous management actions, including actions potentially affecting water quality management, wetland habitat management, agricultural habitat management, hunting and other visitor resources, land acquisition priorities, and changes in the management of other refuge resources.

As part of this economic assessment, regional economic conditions in the study area are described, including the economic contribution that current operations of the five refuges make to the regional economy. These characterizations were derived using current refuge conditions including operations data as informational input to the IMPLAN input-output model (Minnesota IMPLAN Group, Inc. 2010 and 2013). The effects of implementing each of the CCP management alternatives on regional economic conditions are evaluated and described. These effects could be caused by potential changes in NWRC administration, potential changes in levels of NWRC wildlife-dependent visitation, and potential changes in agricultural production on

NWRC lands. Instead of having a small set of thematic alternatives; the analysis brackets from lowest to highest the possible impacts of a large number of combinations.

These potential effects were identified through collaboration with NWRC staff (Griggs pers. comm.). Note that Alternative A (the No Action Alternative) serves as a baseline condition for the analyses; consequently, implementation of Alternative A , which proposes continuation of current management program at all refuges, would result in the economic effects described below under existing conditions.

Regional Economic Conditions

The Klamath Basin NWRC study area is in a rural area with few nearby communities. Klamath Falls, Oregon, is the largest city near the refuge complex, with an estimated 2010 population of more than 20,000 (U.S. Census Bureau 2010). Among study area communities, Klamath Falls provides the greatest array of amenities (e.g., hotels, restaurants, retail stores) for visitors to the region. Some of the smaller communities in the study area, such as Tulelake and Dorris, also provide visitor amenities, such as motels, restaurants, and gas stations. Tulelake is a town of 1,010 residents located on State Route 139 in California, just east of the Tule Lake and Lower Klamath refuges and west of Clear Lake Refuge. The town of Dorris, located in California along U.S. 97 west of Lower Klamath Refuge, had an estimated population of 939 in 2010. Communities in Oregon near the NWRC include Chiloquin (population 734 in 2010), located east of the Upper Klamath Refuge; Merrill (population 844 in 2010), located north of Tule Lake and Lower Klamath Refuges; and Malin (population 805 in 2010), located east of Merrill.

Refuge operations contribute to levels of industry output, employment, and personal income in the study region. The sectors of the study area's economy that most benefit from refuge operations include the agricultural sector, the federal government sector, and various related sectors that collectively comprise the recreation and tourist-servicing industry, including food and beverage stores, gasoline stations, miscellaneous retailers, hotels and motels, and food services and drinking places. Industry output represents the dollar value of an industry's total production. Value of production is usually measured as the market value of goods and services sold by an industry. Employment is the number of jobs in each industry, including both full- and part-time workers and self-employed individuals. Personal income mostly consists of the wages, salaries, and value of benefits of the affected work force.

Economic activity of the directly-affected sectors also indirectly affects economic conditions in other sectors of the study area's economy as spending in the directly affected businesses and the government, and its employees, ripple through the study area economy. For this analysis, economic conditions in the study area are characterized by levels of industry output (value of total production), jobs, and personal income in 2010.

As shown in Table 1, economic output in the study area totaled about $6.8 billion in 2010, with Oregon's Klamath County generating the largest shares of output, followed by Siskiyou and Modoc counties in California. Considered together, the three major sectors most sensitive to refuge management and operations - agriculture, recreation and tourist servicing, and federal government - accounted for about 24 percent of total industry output in the study area in 2010.

The number of jobs and levels of personal income are key indicators of the importance of these sectors to the study area economy. As derived from data in Tables 2 and 3, the three major sectors considered most sensitive to refuge management (agriculture, federal government, and various sectors that collectively comprise the recreation and tourist-servicing industry) accounted for about 28 percent of the jobs and 24 percent of the personal income in the study area in 2010. Agriculture accounted for about 7 percent of total employment and 3 percent of personal income in the study area, with Klamath and Siskiyou counties accounting for most of the agricultural employment and income. Federal government employment generated about 3 percent of study area employment, but nearly 10 percent the area's employee compensation in 2010, with Siskiyou County accounting for the largest share.
The sectors comprising the recreation and tourist-servicing industry - including food and beverage stores, gasoline stations, retail businesses, hotels and motels, and food services and drinking establishments - accounted for about 18 percent of study area-wide employment and 11 percent of personal income, with more than half of the retail employment and income located in Klamath County.

Estimates of the contribution that the five refuges make to the three-county regional economy are identified below in the Contribution to the Regional Economy of Existing NWRC Operations, Refuge Visitor-Related Spending, and Agricultural Production on NWRC Lands section.

Current Klamath Basin NWRC Operations and Related Economic Activities

On an ongoing basis, the Klamath Basin NWRC contributes to the regional economy through expenditures made by the federal government to manage, operate, and maintain the five wildlife refuges; by the regional spending of visitors to the refuges; and by the production of commercial crops on refuge lands. Together, the five wildlife refuges consist of about 156,000 acres.

Lower Klamath Refuge, partially located in both Oregon's Klamath County and California's Siskiyou County, was established as the nation's first waterfowl refuge in 1908 by President Theodore Roosevelt because of its tremendous wildlife resources. Its size was reduced by subsequent executive orders and later increased by the 1964 Kuchel Act and new land acquisitions. The combined area of Lower Klamath Refuge, the Kuchel Act tracts, and the new acquisitions is 51,247 acres,

Clear Lake Refuge was established in 1911 as a "preserve and breeding ground for native birds" (Executive Order 1332). Clear Lake Refuge is located in northern California, just south of the Oregon border in Modoc County. The refuge encompasses approximately 46,460 acres, including the 20,000-acre Clear Lake Reservoir and 26,000 acres of upland habitat. Clear Lake Reservoir is a component of the Klamath Project and is the primary water source for agricultural lands in the eastern half of the Klamath Basin. No croplands, however, are located within Clear Lake Refuge.

Tule Lake Refuge is located in extreme northern California in Modoc and Siskiyou counties, approximately 6 miles west of the town of Tule lake, California. The refuge was established by President Calvin Coolidge on October 4, 1928 via Executive Order Number 4975 and was amended by two subsequent Executive Orders (Number 5945 dated November 4, 1928, and Number 7341 dated April 10, 1936). The Executive Order language states that the lands are to be managed "... as a Refuge and breeding ground for wild birds and animals." Tule Lake Refuge is home to the refuge complex headquarters and visitor center. The refuge consists of 39,116 acres, including two open water sumps (reservoirs totaling 13,000 acres) surrounded by approximately 17,000 acres of cropland.

Upper Klamath Refuge was established in 1928 as a preserve and breeding ground for wild birds and animals. It is comprised of approximately23,000 acres of mostly freshwater marsh and open water with approximately 30 acres of forested uplands. Upper Klamath Refuge is located in Klamath County, Oregon, approximately 35 miles north of the California border. It consists of three units: Hanks Marsh at the south end of Upper Klamath Lake, Upper Klamath Marsh at the north end, and the more recently acquired Agency/Barnes unit. Upper Klamath Lake is adjacent to the east boundary of the Refuge. No croplands are located within the Upper Klamath Refuge boundary.

Bear Valley Refuge, located in Klamath County just north of the California border, was established in 1978 to protect a major night roost site for wintering bald eagles. The Refuge consists of 4,200 acres, primarily of old growth ponderosa pine, incense cedar, and white and Douglas fir. No croplands are included within the refuge.

NWRC Administration

Klamath Basin NWRC facilities include shops, vehicle storage, offices, residences, fueling stations, pump houses, hazardous material storage, visitor centers, and wildlife rehabilitation buildings. These facilities support refuge maintenance and management activities and operations, as well as visitor services. The NWRC administrative headquarters and visitor center are located at the northwest corner of Tule Lake Refuge, near the community of Tulelake in Siskiyou County. Most of the heavy equipment and other refuge equipment and vehicles are parked in common areas at Tule Lake and Lower Klamath refuges. Routine maintenance activities of refuge equipment occur in these areas.

During the last (2014-15) fiscal year, the Service spent $3,939,570 to operate and maintain the five refuges, including $3,040,767 for salaries, and $898,803 for all other expenses.

Table 1. Total economic output[a] by industry in study area counties 2010 (Millions of 2015 Dollars)

County	Industry Category								
	Agriculture[a]	Food & Beverage Stores	Gasoline Stations	Miscellaneous Retailers[b]	Hotels & Motels[c]	Food Services & Drinking Places	Federal Government[d]	All Other Sectors	Total[e]
Klamath (OR)	237	38	21	181	32	103	73	2,818	3,502
Modoc (CA)	161	6	7	15	1	8	37	322	557
Siskiyou (CA)	304	30	44	90	38	77	96	2,053	2,734
TOTAL[e]	702	74	72	287	71	189	206	5,194	6,794

Source: Minnesota IMPLAN Group 2010 base data, ran in 2012.

Notes:
[a] Includes crop, cattle and livestock, dairy, milk production, poultry and egg production, nursery and floriculture production, and agricultural and forestry support services sectors.
[b] Includes retailers, excluding food and beverage stores and gasoline stations.
[c] Also includes other types of accommodations.
[d] Excludes federal enterprises and military and U.S. Postal Service sectors.
[e] Totals may differ from the summation of components due to rounding.

Table 2. Total employment[a] by industry in study area counties, 2010

County	Industry Category								
	Agriculture[b]	**Food & Beverage Stores**	**Gasoline Stations**	**Miscellaneous Retailers[c]**	**Hotels & Motels[d]**	**Food Services & Drinking Places**	**Federal Government[e]**	**All Other Sectors**	**Total [f]**
Klamath (OR)	1,842	625	276	2,905	369	1,844	696	23,675	32,232
Modoc (CA)	679	96	32	223	9	154	359	2,906	4,458
Siskiyou (CA)	1,550	470	268	1,304	398	1,307	946	15,235	21,478
TOTAL [f]	4,071	1,191	576	4,432	776	3,305	2,001	41,816	58,168

Source: Minnesota IMPLAN Group 2010 base data, ran in 2012.

Notes:
[a] Includes full- and part-time jobs.
[b] Includes crop, cattle and livestock, dairy, milk production, poultry and egg production, nursery and floriculture production, and agricultural and forestry support services sectors.
[c] Includes retailers, excluding food and beverage stores and gasoline stations.
[d] Also includes other types of accommodations.
[e] Excludes federal enterprises and military and U.S. Postal Service sectors.
[f] Totals may differ from the summation of components due to rounding.

Table 3. Total personal income compensation[a] by industry in study area counties 2010 (Millions of 2015 Dollars)

County	Industry Category								
	Agriculture[b]	Food & Beverage Stores	Gasoline Stations	Miscellaneous Retail[c]	Hotels & Motels[d]	Food Services & Drinking Places	Federal Government[e]	All Other Sectors	Total [f]
Klamath (OR)	25.3	17.2	6.5	67.4	7.4	30.3	65.6	860.5	1080.2
Modoc (CA)	11.2	2.2	0.1	5.1	0.1	2.0	32.4	86.9	140.0
Siskiyou (CA)	20.0	12.9	6.1	29.0	6.6	20.0	84.7	504.1	683.5
TOTAL [f]	56.5	32.3	12.7	101.5	14.1	52.3	182.7	1451.6	1903.7

Source: Minnesota IMPLAN Group 2010 base data, ran in 2012.

Notes:
[a] Includes wages, salary, and value of benefits of employees (employee compensation); excludes proprietary income and other property-type income.
[b] Includes crop, cattle and livestock, dairy, milk production, poultry and egg production, nursery and floriculture production, and agricultural and forestry support services sectors.
[c] Includes retailers, excluding food and beverage stores and gasoline stations.
[d] Also includes other types of accommodations.
[e] Excludes federal enterprises and military and U.S. Postal Service sectors.
[f] Totals may differ from the summation of components due to rounding.

As part of base budget expenditures, the Service spends about three million dollars on salaries, employing 27 employees who assist with management, operations, and maintenance of the five refuges being analyzed in the Klamath Basin NWRC and its programs. According to the Service, all of the employees reside in the study area, with most of the administrative staff presumably living near the administration/operations headquarters near the community of Tulelake (Siskiyou County). Although not presented in Table 4, base goods and services expenditures across the three budgets generally fall into the following categories: utilities (25 percent), fuel (23 percent), vehicle and equipment replacement (20 percent), vehicle repair (18 percent), parts and building materials (9 percent), and office supplies (5 percent) (Barry pers. comm. 2013).

Table 4. Fiscal Year 2014-15 budget expenditures and data for the Klamath Basin National Wildlife Refuge Complex (2015 Dollars)

Category	Lower Klamath NWR	Clear Lake NWR	Tule Lake NWR	Bear Valley NWR	Upper Klamath NWR	Five Refuge Total
Salary Expenditures	$1,364,508	$303,224	$1,061,284	$151,612	$160,138	$3,040,767
All Other Expenditures	$404,461	$89,880	$314,581	$44,940	$44,940	$898,803
Total Budget	$1,768,970	$393,104	$1,375,865	$196,552	$205,078	$3,939,570
RSS Transfers[a]	$11,961	$8,105	$19	$6,417	$19,951	$46,452
Kuchel Act PILT Payment	$10,556	-	$502,244	-	-	$512,800
Number of Jobs	-	-	-	-	-	27

Source: Griggs pers. comm.

Notes:
[a]RSS transfer data is from 2014 and indexed to 2015 dollars.

Visitor Use

Public use occurs at all five affected complex refuges. Public use opportunities at the study area's five NWRC refuges are summarized as follows.

- Lower Klamath Refuge: The Service maintains photo and hunting blinds, a wildlife overlook, a 10-mile auto tour route with signs, and vehicle pull-offs. The refuge offers a mix of marsh hunting for both boat and walk-in hunters, and field hunting for geese and pheasant in both grain stubble and areas of standing grain.

- Clear Lake Refuge: Except for waterfowl hunting and a limited antelope hunt, the refuge is closed to all public entry. No facilities are located within the refuge. Parking for walk-in hunting access is available along roads leading to the refuge. The area is not heavily hunted, probably due to the limited, difficult access. Wildlife viewing is possible from a road along the southern edge of the refuge.

- Tule Lake Refuge: Recreation opportunities on the refuge include the visitor center, wildlife viewing areas, a wildlife auto route, waterfowl and pheasant hunting, photography blinds, and a canoe trail. The hunt areas include waterfowl- and pheasant-only areas and joint waterfowl/pheasant areas. The auto tour and interpretive areas around the visitor center are open to the public year round. The canoe trail is open seasonally.

- Upper Klamath Refuge: The refuge offers waterfowl hunting, fishing, wildlife observation and photography, environmental education, and interpretation. Access to the refuge, however, is primarily by boat because of the presence of flooded wetlands most of the year. Additionally, walk-in hunting access is available for hunters who park off-site in nearby areas. No facilities are located within the refuge, but a canoe trail with signs through the wetlands provides wildlife observation opportunities.

- Bear Valley Refuge: The refuge was established, in part, to protect roosting bald eagles from human disturbance. Accordingly, the Refuge is closed to all public entry, except for walk-in deer hunting before November 1. From December through mid-March, the refuge offers excellent opportunities to observe fly-outs of large numbers of bald eagles from their night roost from an observation site off U.S. Route 97.

For purposes of this economic assessment2015 data for visitors by type of activity to each of the refuges, as reported by Kenneth Griggs the Deputy Project Leader, were used in the calculations. The Lower Klamath NWR recreation is dependent on water deliveries therefore the data is displayed as expected values[1]. The 2015 data is as follows:

[1] The visitor use information was generated by Stacy Freitas, Wildlife Refuge Specialist, and Ken Griggs, Deputy Project Leader, at Klamath Basin NWRC. Both hunter and non-consumptive user (wildlife photography,

- Lower Klamath NWR: 8,000 to 16,000 hunting visits, and 27,300 to 35,800 wildlife viewing and non-consumptive visits

- Clear Lake NWR: 75 hunting visits
- Tule Lake NWR: 13,750 hunting visits, and 40,300 wildlife viewing and non-consumptive visits
- Upper Klamath NWR: 4,000 hunting visits, 10,000 wildlife viewing visits, and 5,000 fishing visits

- Bear Valley NWR: 280 hunting visits

Note that these values represent the numbers of 8-hour visits to each refuge, which were derived by converting estimates of the number of people recreating and average hours per visit.

Based on spending profiles for local (within 50 miles) and non-local residents who visited the Klamath Basin NWRC, as reported in the U.S. Fish and Wildlife's 2006 National Survey of Fishing, Hunting and Wildlife Related Recreation, total visitor-related expenditures made within the three-county study area were estimated. Annual spending in the study area by visitors to the Klamath Basin NWRC is estimated at $4,225,000 (2015 dollars). Of this total, spending in food and drink establishments and for transportation (excluding air transport) each accounted for about 31 percent of total regional spending, and lodging expenditures accounted for about 24 percent. Non-local visitors accounted for an estimated 63 percent of total visitor-related spending within the study region.

Agricultural Production on NWRC Lands

Of the Klamath Basin NWRC's five refuges in this study four of them have agricultural production, only Bear Valley NWR does not. On the Lower Klamath and Tule Lake Refuges, properties are farmed under both a lease land program and a cooperative farming program. While the lease lands are under the administrative jurisdiction of the Klamath Basin Refuges, the U.S. Bureau of Reclamation (Reclamation) administers the agricultural leasing program via a Cooperative Agreement. The Service manages the cooperative farming on the refuges.

The lease and program is operated under the auspices of the Kuchel Act (Public Law 88-567), passed by Congress in 1964. The Act was intended to ensure that certain refuge habitats are preserved for migratory waterfowl while allowing continued agricultural practices consistent with waterfowl conservation. Leases are awarded in five-year increments with the option to renew each year. Approximately 20 percent of the leases are put out for bid each year

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observation, etc.) numbers were generated using count data and staff observations and estimation. A hunt check station on Tule Lake NWR, where hunters are assigned fields and blinds was used to provide actual count data on hunter uses of portions of TLNWR. However, many hunters in other portions of TLNWR, LKNWR, UKNWR, CLNWR, and BVNWR, are not required to go through a check station. In these instances, daily observation by biological and visitor services staff was used to estimate numbers of individuals per day. This was extrapolated to a 100 day season in the case of waterfowl hunting.

Count data of visitors using the Complex Visitor Center was used to partially estimate the number of visitors enjoying wildlife photography and wildlife observation. Again, not all visitors come into the visitor center, so observation and estimation were employed to generate the numbers provided.

with the remaining available for renewal. Although up to 25 percent of lease land areas may be planted to row crops, the lease lands at Tule Lake Refuges are currently used by local growers for the commercial production of conventional and organic alfalfa, grass hay, potato, onion, horseradish, and small grains, and for livestock grazing. On Lower Klamath Refuge, lease land farming is limited to grains and pasture as well as haying and grazing. Row crops are not allowed on Lower Klamath Refuge. Approximately 5,600 acres of land on the Lower Klamath Refuge and 14,900 acres of land on the Tule Lake Refuge were leased and farmed in accordance with the Kuchel Act in 2015 (Pelz pers. comm.). The Lease Land program has generated an average of $3.6 million annually in lease revenue from 2006 through 2015, which is retained by the Bureau of Reclamation (Green 2016). The Bureau of Reclamation is not obligated to use this revenue for habitat enhancement work on the refuges. The Service currently receives no direct revenues from the program.

Acreage farmed on the two refuges under the Cooperative Farmland program are dedicated exclusively to cereal grain (usually barley) production on the Lower Klamath Refuge and grains, potatoes, and onions on the Tule Lake Refuge. The farmer is allowed to harvest three-quarters of the crop in consideration of his expense and labor for tilling, seeding, and fertilizing the crop. The one-fourth that the farmer is not allowed to harvest is left standing in the field for the benefit of wildlife. The farmer provides all seed, fertilizer, pesticide, equipment, fuel, and labor while the Service provides the land, water, and irrigation services. Approximately 2,400 acres of land on the Tule Lake Refuge, and 4,500 to 5,000 acres of land on the Lower Klamath Refuge, were cooperatively farmed in 2011 through 2015 (Barry pers. comm.).

Combining both programs, farmed areas in the two refuges totaled approximately 27,900 acres in 2014, including 10,000 acres within the Lower Klamath Refuge and 16,000 in the Tule Lake Refuge (Table 5). Based on the average yields and prices shown in Table 5, the value of production on harvested acreage totaled an estimated $30.0 million in that year, including approximately $5.6 million on Lower Klamath Refuge properties and $24.4 million on Tule Lake Refuge properties. As discussed previously, a portion of this annual gross production income received by farmers is paid to the Bureau of Reclamation through the Lease Land program.

Contribution to the Regional Economy of Existing NWRC Operations, Refuge Visitor-Related Spending, and Agricultural Production on Refuge Lands

Existing activities occurring on the NWRC provide regional economic benefits to businesses and households throughout the study area, but mostly for those communities near the actively managed refuge lands, particularly Tule Lake, where the NWRC is headquartered. As described above, these activities include NWRC administration that generates salaries and procures goods and services needed for refuge management, visitors recreating at the refuges who also spend in the local economy, and agricultural production on NWRC lands.

Based on modeling results from the IMPLAN input-output model, current NWRC administration is estimated to directly and indirectly support about 31 jobs in the study area (Table 9). Of these jobs, an estimated 21 are federal employees directly engaged in NWRC management on these five refuges, operations and maintenance activities. The remaining 9 jobs are indirectly generated by the local procurement of goods and services needed for NWRC operations and by the spending of employees directly and indirectly supported by NWRC activities. Estimated personal income and industry output directly and indirectly generated in the study area by existing NWRC administration totaled about $1.8 million and $4.0 million, respectively (in 2015 dollars) (Table 9).

Based on IMPLAN modeling results, annual spending by public visitors to the NWRC supports an estimated 31 jobs in the study area economy and generates about $775,000 (in 2015 dollars) annually in personal income (Table 23). Additionally, visitor-related spending generated an estimated $3.6 million in industry output in the study area.

The production of crops on the NWRC properties are estimated to support about 589 to 659 jobs and $12.7 to 14.5 million in personal income in the study area, based on IMPLAN modeling results (Table 11). Industry output attributable to agricultural production on NWRC properties totals an estimated $59.9 to $66.5 million.

Table 5. Agriculture - Crops: Productivity (2015 Dollars)

Category	Crops	Yield per Acre	Value per Unit	Average Group Yield per Acre	Average Group Value per Unit	Average Sales per Acre
Alfalfa	Alfalfa (ton)	5.25	$186	5.25	$186	$976
Grains	Barley (ton)	2.75	$222	2.6175	$238	$623
	Oats (ton)	2.47	$261			
	Rye (ton)	1.95	$214			
	Wheat (ton)	3.3	$255			
Hay	Hay (ton)	4.1	$148	4.1	$148	$606
Row Crops	Onions (cwt)	503	$6.84	508	$7.88	$4,003
	Potatoes (cwt)	513	$8.92			

Notes:
[a] Represents average yield per acre in Siskiyou County from 2007-2011, as reported in annual Siskiyou County crop and livestock reports.
[b] Represents average gross value of production per unit from 2007-2011, as reported in annual Siskiyou County crop and livestock reports.

Table 6. Agriculture - Cattle: Grazing Productivity

(2015 Dollars)

Unit (Scenario)	Acres	Cows	Cows Per Acre	Sale Price per Cow	Average Sales per Acre
Lower Klamath NWR	11,225	3,600	0.32	$1,095	$351
Upper Klamath NWR (Low)	1,400	560	0.40	$1,095	$438
Upper Klamath NWR (High)	2,200	560	0.25	$1,095	$279
Clear Lake NWR	5,500	600	0.11	$1,095	$119
Tule Lake NWR[c]	-	-	-	-	-
Bear Valley NWR[c]	-	-	-	-	-
Total (Low)	**18,125**	**4,760**	**0.26**	**-**	**-**
Total (High)	**18,925**	**4,760**	**0.25**	**-**	**-**

Notes:
[a]Cow price is $1,095 (USDA NASS 2012).
[b]Acres for productivity calculations may not match acres in alternative 1 (No Action).
[c]No grazing exists on the Tule Lake NWR and the Bear Valley NWR under the No Action Alternative.

Table 7. Crop Production - Acres and Sales (2015 Dollars)

Area & Scenario	Acres Total Grain (sold)	Sales Grain	Row Crops	Sales Row Crops	Alfalfa	Sales Alfalfa	Haying	Sales Haying	Total Acres in Production for Sales	Total Sales
Lower Klamath NWR - Alt A (.2)	1,200	$747,558	0	$0	0	$0	2,000	$1,211,948	3,200	$1,959,506
Lower Klamath NWR - Alt A (.8)	7,200	$4,485,348	0	$0	0	$0	2,000	$1,211,948	9,200	$5,697,296
Lower Klamath NWR - Alt A KBRA (.2)	3,700	$2,304,971	0	$0	0	$0	2,000	$1,211,948	5,700	$3,516,919
Lower Klamath NWR - Alt A KBRA (.8)	7,200	$4,485,348	0	$0	0	$0	2,000	$1,211,948	9,200	$5,697,296
Tule Lake NWR- Alt A	10,990	$6,846,136	6,374	$25,515,377	1,936	$1,888,827	0	$0	19,300	$34,250,340
Upper Klamath NWR - Alt A	0	$0	0	$0	0	$0	200	$121,195	200	$121,195
Clear Lake NWR - Alt A	0	$0	0	$0	0	$0	0	$0	0	$0
Bear Valley NWR - Alt A	0	$0	0	$0	0	$0	0	$0	0	$0
Total Minimum	*12,190*	*$7,593,694*	*6,374*	*$25,515,377*	*1,936*	*$1,888,827*	*2,200*	*$1,333,143*	*22,700*	*$36,331,041*
Total Maximum	*18,190*	*$11,331,484*	*6,374*	*$25,515,377*	*1,936*	*$1,888,827*	*2,200*	*$1,333,143*	*28,700*	*$40,068,831*

Source: Barry pers. comm.

Table 8. Agriculture - Cattle: Acres and Sales (2015 Dollars)

Unit (Scenario)	Acres	Cows Per Acre	Cows	Sale Price per Cow	Average Sales per Acre	Sales
Lower Klamath NWR[a]	12,500	0.32	4,000	$1,095	$350	$4,380,000
Upper Klamath NWR (Low)	1,400	0.4	560	$1,095	$438	$613,200
Upper Klamath NWR (High)	2,200	0.25	560[a]	$1,095	$274	$613,200
Clear Lake NWR	5,000	0.11	550	$1,095	$120	$602,250

Notes:
[a]AUMs in Upper Klamath NWR are not variable. The number of acres the cows can occupy is.
[a]For all water delivery schedules

Table 9. Regional economy benefits of current NWRC administration

Category	Lower Klamath NWR	Clear Lake NWR	Tule Lake NWR	Bear Valley NWR	Upper Klamath NWR	Five Refuge Total
Salary Expenditures	*$1,364,508*	*$303,224*	*$1,061,284*	*$151,612*	*$160,138*	*$3,040,767*
Salary Expenditures Less Benefits (used for calculations)	*$955,156*	*$212,257*	*$742,899*	*$106,128*	*$112,097*	*$2,128,537*
Output	$1,367,783	$303,952	$1,063,832	$151,976	$160,522	$3,048,065
Employment Compensation	$683,892	$151,976	$531,916	$75,988	$80,261	$1,524,032
Jobs	9.6	2.1	7.4	1.1	1.1	21.3
All Other Expenditures[a]	*$404,461*	*$89,880*	*$314,581*	*$44,940*	*$44,940*	*$898,803*
Output	$410,303	$91,178	$319,125	$45,589	$45,589	$911,785
Employment Compensation	$102,839	$22,853	$79,986	$11,427	$11,427	$228,532
Jobs	4.0	0.9	3.1	0.4	0.4	8.8
Total Budget	*$1,768,970*	*$393,104*	*$1,375,865*	*$196,552*	*$205,078*	*$3,939,570*
Output	$1,778,086	$395,130	$1,382,956	$197,565	$206,112	$3,959,850
Employment Compensation	$786,731	$174,829	$611,902	$87,415	$91,688	$1,752,565
Jobs	13.5	3.0	10.5	1.5	1.6	30.1

Source: IMPLAN input-output model run results, based on NWRC budget information provided by Griggs pers. comm.

Notes:
Effects include direct and secondary (indirect and induced) effects of existing average annual expenditures for refuge management.
Employment (jobs) includes full- and part-time jobs.
[a]65% of All Other Expenditures are local and used for the IMPLAN runs.

Table 10. Regional economic benefits of existing cattle production, (2015 Dollars)

Area	Sales	Output	Employment Compensation	Jobs
Lower Klamath NWR	$4,380,000	$7,269,804	$606,949	36.2
Upper Klamath NWR	$613,200	$1,017,772	$84,973	5.1
Clear Lake NWR	$602,250	$999,598	$83,456	5.0
Total	$5,212,200	$8,651,066	$722,270	43.1

Table 11. Regional economic benefits of existing agricultural crop production, (2015 Dollars)

Area & Scenario	Grain Output	Grain Employment Compensation	Grain Jobs	Row Crops Output	Row Crops Employment Compensation	Row Crops Jobs	Hay & Alfalfa Output	Hay & Alfalfa Employment Compensation	Hay & Alfalfa Jobs	Total Output	Total Employment Compensation	Total Jobs
Lower Klamath NWR - Alt A (.2)	1,320,249	177,490	7.0	0	0	0.0	2,140,400	177,490	7.0	$3,460,648	$354,981	14.0
Lower Klamath NWR - Alt A (.8)	7,921,492	1,064,942	42.0	0	0	0.0	2,140,400	1,064,942	42.0	$10,061,892	$2,129,885	83.9
Lower Klamath NWR - Alt A KBRA (.2)	4,070,767	547,262	21.6	0	0	0.0	2,140,400	547,262	21.6	$6,211,166	$1,094,524	43.1
Lower Klamath NWR - Alt A KBRA (.8)	7,921,492	1,064,942	42.0	0	0	0.0	2,140,400	1,064,942	42.0	$10,061,892	$2,129,885	83.9
Tule Lake NWR- Alt A	12,090,837	1,625,457	64.1	40,808,837	9,118,266	446.7	3,335,822	1,625,457	64.1	$56,235,496	$12,369,179	574.8
Upper Klamath NWR - Alt A	0	0	0.0	0	0	0.0	214,040	0	0.0	$214,040	$0	0.0
Clear Lake NWR - Alt A	0	0	0.0	0	0	0.0	0	0	0.0	$0	$0	0.0
Bear Valley NWR - Alt A	0	0	0.0	0	0	0.0	0	0	0.0	$0	$0	0.0
Total Minimum	*13,411,086*	*$1,802,947*	*71*	*$40,808,837*	*9,118,266*	*$447*	*5,690,262*	*$1,802,947*	*71*	*$59,910,184*	*$12,724,160*	*588.8*
Total Maximum	*20,012,329*	*$2,690,399*	*106*	*$40,808,837*	*9,118,266*	*$447*	*5,690,262*	*$2,690,399*	*106*	*$66,511,428*	*$14,499,064*	*658.8*

Source: IMPLAN input-output model run results, based on the estimated value of agricultural production on NWRC properties in 2015 (Table 5).

Notes:
Effects include direct and secondary (indirect and induced) effects.
[a] Employment includes full- and part-time jobs.

Economic Effects of the NWRC Management Alternatives

This report section identifies potential economic effects of the management alternatives proposed for each of the five refuges. From the perspective of economic effects, alternative management actions would be expected to have differing (and, in some cases, offsetting) effects on governmental spending for NWRC operations and management, on the amount of spending by visitors to the NWRC, and on agricultural production activity. The effects of refuge-related activities would, in turn, affect levels of industrial output, employment, and personal income within the three-county study region. As previously noted, the effects described below represent expected changes from current conditions (Alternative A, the No Action Alternative).

Lower Klamath NWR

<u>Alternative B</u>

Under Alternative B, implementation of management activities in the Lower Klamath NWR could result in:

- a short-term increase in refuge spending and regional economic activity due to construction or modification of facilities (Table 17);
- a minor increase in overall refuge operations spending and related regional economic effects due to increased staffing (Table 17);
- a moderate increase in visitation, visitor spending, and related regional economic effects compared to Alternative A (Table 23) due to improved recreation; and
- a decrease in farming production and related regional economic effects due to shifts from grain to irrigated pasture compared to Alternative A (Table 15).

<u>Alternative C</u>

Under Alternative C, implementation of management activities in the Lower Klamath NWR could result in:

- a short-term increase in refuge spending and regional economic activity due to construction or modification of facilities (Table 17);
- a minor increase in overall refuge operations spending and related regional economic effects due to increased staffing (Table 17);
- a moderate increase in visitation, visitor spending, and regional economic effects compared to Alternative A (Table 23) due to improved recreation; and
- a decrease in farming production and related regional economic effects due to shifts from grain to irrigated pasture compared to Alternative A (Table 15).

- an increase in cattle production and related regional economic effects due to increases in area grazed compared to Alternative A (Table 16).

Alternative D

Under Alternative D, implementation of management activities in the Lower Klamath NWR could result in:

- a large short-term increase in refuge spending and regional economic activity due to construction or modification of facilities associated with the Big Pond unit (Table 17);
- a minor increase in overall refuge operations spending and related regional economic effects due to increased staffing (Table 17);
- a moderate increase in visitation, visitor spending, and regional economic effects compared to Alternative A (Table 23) due to improved recreation; and
- a decrease in farming production and related regional economic effects due to shifts from grain to irrigated pasture compared to Alternative A (Table 15).
- an increase in cattle production and related regional economic effects due to increases in grazing compared to Alternative A (Table 16).

Clear Lake NWR

Alternative B

Under Alternative B, implementation of management activities in the Clear Lake NWR could result in:

- a one-time increase in refuge spending and regional economic activity due to public facility improvements (Table 18);
- little to no net change in overall refuge operations spending, thereby resulting in operations spending levels and related regional economic effects that would be similar to those for Alternative A (Table 18);
- a minor increase in visitation, visitor spending, and regional economic effects compared to Alternative A (Table 23) due to improved recreation; and
- an increase in agricultural production due more grazing acres being made available (Table 16)

Table 12. Cattle: Grazing Productivity

Unit (Scenario)	Acres	Cows	Cows Per Acre	Sale Price per Cow	Average Sales per Acre	Sales
Clear Lake NWR (Alternative A)	5500	600	0.11	$1,095	$119	$657,000
Clear Lake NWR (Alternative B increase, Low)	3000	300	0.10	$1,095	$110	$328,500
Clear Lake NWR (Alternative B increase, High)	3000	500	0.17	$1,095	$183	$547,500

(Smith pers. Comm. 2016)

Tule Lake NWR

Alternative B

Under Alternative B, implementation of management activities in the Tule Lake NWR could result in:

- a short-term increase in refuge spending and regional economic activity due to construction or modification of facilities (Table 19);
- a minor increase in overall refuge operations spending and related regional economic effects due to increased staffing (Table 19);
- a moderate increase in visitation, visitor spending, and regional economic effects compared to Alternative A (Table 23) due to improved recreation; and
- a decrease in agricultural production and related regional economic activity compared to Alternative A (Table 15) due to 1,250 acre increase in standing (unharvested) grain.

Alternative C

Under Alternative C, implementation of management activities in the Tule Lake NWR could result in:

- a short-term increase in refuge spending and regional economic activity due to construction or modification of facilities (Table 19);
- a minor increase in overall refuge operations spending and related regional economic effects due to increased staffing (Table 19);

- a moderate increase in visitation, visitor spending, and regional economic effects compared to Alternative A (Table 23) due to improved recreation;

- a possible decrease in agricultural production and related regional economic activity levels compared to Alternative A (Table 15) due to an expansion of the Walking Wetlands program (up to 3,000 acres total), potentially leading to less crop production but also to shifts in crop types (possibly including greater production of more valuable organic crops).

Upper Klamath NWR

<u>Alternative B</u>

Under Alternative B, implementation of management activities in the Upper Klamath NWR could result in:

- a short-term, one-time increase in refuge spending and regional economic activity due to construction of facilities (Table 21);

- little to no net change in overall refuge operations spending, thereby resulting in operations spending levels and related regional economic effects that would be similar to those for Alternative A (Table 21);

- a moderate increase in visitation and visitor spending due to improved recreation opportunities, resulting in a moderate increase in regional economic effects compared to Alternative A (Table 23); and

- no agricultural production effects.

Bear Valley NWR

<u>Alternative B</u>

Under Alternative B, implementation of management activities in the Bear Valley NWR could result in:

- a short-term increase in refuge spending and regional economic activity due to construction of public access facilities (Table 20);

- little to no net change in overall refuge operations spending, thereby resulting in operations spending levels and related regional economic effects that would be similar to those for Alternative A (Table 20);

- a moderate increase in visitation and visitor spending due to improved recreation opportunities, resulting in a moderate increase in regional economic effects compared to Alternative A (Table 23); and

- no agricultural production effects. (note: no agricultural production occurs at this refuge).

Table 13: Crop Production Acres and Sales: All Alternatives and Changes

Area & Scenario	Acres Total Grain (sold)	Sales Grain	Row Crops	Sales Row Crops	Alfalfa	Sales Alfalfa	Haying	Sales Haying	Total Acres in Production for Sales	Total Sales
Lower Klamath NWR - Alt A (.2)	1,200	$747,558	0	$0	0	$0	2,000	$1,211,948	3,200	$1,959,506
Lower Klamath NWR - Alt A (.8)	7,200	$4,485,348	0	$0	0	$0	2,000	$1,211,948	9,200	$5,697,296
Lower Klamath NWR - Alt A KBRA (.2)	3,700	$2,304,971	0	$0	0	$0	2,000	$1,211,948	5,700	$3,516,919
Lower Klamath NWR - Alt A KBRA (.8)	7,200	$4,485,348	0	$0	0	$0	2,000	$1,211,948	9,200	$5,697,296
Lower Klamath NWR - Alt B (.2)	1,050	$654,113	0	$0	0	$0	2,000	$1,211,948	3,050	$1,866,061
Change Alt B (.2)	-150	-$93,445	0	$0	0	$0	0	$0	-150	-$93,445
Lower Klamath NWR - Alt B (.8)	3,350	$2,086,933	0	$0	0	$0	2,000	$1,211,948	5,350	$3,298,881
Change Alt B (.8)	-3,850	-$2,398,415	0	$0	0	$0	0	$0	-3,850	-$2,398,415
Lower Klamath NWR - Alt B KBRA (.2)	2,850	$1,775,450	0	$0	0	$0	2,000	$1,211,948	4,850	$2,987,398
Change Alt B KBRA (.2)	-850	-$529,520	0	$0	0	$0	0	$0	-850	-$529,520
Lower Klamath NWR - Alt B KBRA (.8)	4,950	$3,083,677	0	$0	0	$0	2,000	$1,211,948	6,950	$4,295,625
Change Alt B KBRA (.8)	-2,250	-$1,401,671	0	$0	0	$0	0	$0	-2,250	-$1,401,671
Lower Klamath NWR - Alt C (.2)	1,250	$778,706	0	$0	0	$0	2,000	$1,211,948	3,250	$1,990,654
Change Alt C (.2)	50	$31,148	0	$0	0	$0	0	$0	50	$31,148
Lower Klamath NWR - Alt C (.8)	5,250	$3,270,566	0	$0	0	$0	2,000	$1,211,948	7,250	$4,482,514
Change Alt C (.8)	-1,950	-$1,214,782	0	$0	0	$0	0	$0	-1,950	-$1,214,782
Lower Klamath NWR - Alt C KBRA (.2)	2,850	$1,775,450	0	$0	0	$0	2,000	$1,211,948	4,850	$2,987,398
Change Alt C KBRA (.2)	-850	-$529,520	0	$0	0	$0	0	$0	-850	-$529,520
Lower Klamath NWR - Alt C KBRA (.8)	4,950	$3,083,677	0	$0	0	$0	2,000	$1,211,948	6,950	$4,295,625
Change Alt C KBRA (.8)	-2,250	-$1,401,671	0	$0	0	$0	0	$0	-2,250	-$1,401,671
Lower Klamath NWR - Alt D (.2)	1,250	$778,706	0	$0	0	$0	2,000	$1,211,948	3,250	$1,990,654
Change Alt D (.2)	50	$31,148	0	$0	0	$0	0	$0	50	$31,148
Lower Klamath NWR - Alt D (.8)	5,250	$3,270,566	0	$0	0	$0	2,000	$1,211,948	7,250	$4,482,514
Change Alt D (.8)	-1,950	-$1,214,782	0	$0	0	$0	0	$0	-1,950	-$1,214,782
Lower Klamath NWR - Alt D KBRA (.2)	3,150	$1,962,340	0	$0	0	$0	2,000	$1,211,948	5,150	$3,174,288
Change Alt D KBRA (.2)	-550	-$342,631	0	$0	0	$0	0	$0	-550	-$342,631
Lower Klamath NWR - Alt D KBRA (.8)	5,250	$3,270,566	0	$0	0	$0	2,000	$1,211,948	7,250	$4,482,514
Change Alt D KBRA (.8)	-1,950	-$1,214,782	0	$0	0	$0	0	$0	-1,950	-$1,214,782
Tule Lake NWR- Alt A	10,990	$6,846,136	6,374	$25,515,377	1,936	$1,888,827	0	$0	19,300	$34,250,340
Tule Lake NWR- Alt B	9,201	$5,731,901	5,994	$23,994,222	3,400	$3,317,154	0	$0	18,595	$33,043,277
Change Alt B	-1,789	-$1,114,235	-380	-$1,521,155	1,464	$1,428,328	0	$0	-705	-$1,207,063
Tule Lake NWR- Alt C	9,201	$5,731,901	4,374	$17,509,297	3,400	$3,317,154	0	$0	16,975	$26,558,352
Change Alt C	-1,789	-$1,114,235	-2,000	-$8,006,080	1,464	$1,428,328	0	$0	-2,325	-$7,691,988
Upper Klamath NWR - Alt A	0	$0	0	$0	0	$0	200	$121,195	200	$121,195
Upper Klamath NWR - Alt B	0	$0	0	$0	0	$0	200	$121,195	200	$121,195
Change Alt B	0	$0	0	$0	0	$0	0	$0	0	$0
Clear Lake NWR - Alt A	0	$0	0	$0	0	$0	0	$0	0	$0
Clear Lake NWR - Alt B	0	$0	0	$0	0	$0	0	$0	0	$0
Change Alt B	0	$0	0	$0	0	$0	0	$0	0	$0
Bear Valley NWR - No Agriculture	-	-	-	-	-	-	-	-	-	-

Table 14: Cattle Production Acres, Cows, and Sales: All Alternatives and Changes

Unit (Scenario)	Acres	Cows Per Acre	Cows	Sale Price per Cow	Average Sales per Acre	Sales[a]
Lower Klamath NWR[b]	12,500	0.32	4,000	$1,095	$350	$4,380,000
Lower Klamath NWR Alt C & D[b]	15,500	0.32	4,960	$1,095	$350	$5,431,200
Change Alt C & D	3,000	-	960	-	-	$1,051,200
Upper Klamath NWR (Low)	1,400	0.4	560	$1,095	$438	$613,200
Upper Klamath NWR (High)	2,200	0.25	560[a]	$1,095	$278.73	$613,200
Clear Lake NWR	5,000	0.11	550	$1,095	$120	$602,250
Clear Lake NWR B	8,000	0.11	880	$1,095	$120	$963,600
Change Alt B	3,000	-	330		-	$361,350

Notes:
[a]AUMs in Upper Klamath NWR are not variable. The number of acres the cows can occupy is.
[b]For all water delivery schedules.

Table 15: Regional economic benefits of Crop Production: All Alternatives and Changes

Area & Scenario	Grain Output	Grain Employment Compensation	Grain Jobs	Row Crops Output	Row Crops Employment Compensation	Row Crops Jobs	Hay & Alfalfa Output	Hay & Alfalfa Employment Compensation	Hay & Alfalfa Jobs	Total Output	Total Employment Compensation	Total Jobs
Lower Klamath NWR - Alt A (.2)	$1,320,249	$177,490	7.0	$0	$0	0.0	$2,140,400	$177,490	7.0	$3,460,648	$354,981	14.0
Lower Klamath NWR - Alt A (.8)	$7,921,492	$1,064,942	42.0	$0	$0	0.0	$2,140,400	$1,064,942	42.0	$10,061,892	$2,129,885	83.9
Lower Klamath NWR - Alt A KBRA (.2)	$4,070,767	$547,262	21.6	$0	$0	0.0	$2,140,400	$547,262	21.6	$6,211,166	$1,094,524	43.1
Lower Klamath NWR - Alt A KBRA (.8)	$7,921,492	$1,064,942	42.0	$0	$0	0.0	$2,140,400	$1,064,942	42.0	$10,061,892	$2,129,885	83.9
Lower Klamath NWR - Alt B (.2)	$1,155,218	$155,304	6.1	$0	$0	0.0	$2,140,400	$155,304	6.1	$3,295,617	$310,608	12.2
Change Alt B (.2)	-$165,031	-$22,186	-0.9	$0	$0	0.0	$0	-$22,186	-0.9	-$165,031	-$44,373	-1.7
Lower Klamath NWR - Alt B (.8)	$3,685,694	$495,494	19.5	$0	$0	0.0	$2,140,400	$495,494	19.5	$5,826,094	$990,988	39.1
Change Alt B (.8)	-$4,235,798	-$569,448	-22.4	$0	$0	0.0	$0	-$569,448	-22.4	-$4,235,798	-$1,138,897	-44.9
Lower Klamath NWR - Alt B KBRA (.2)	$3,135,591	$421,540	16.6	$0	$0	0.0	$2,140,400	$421,540	16.6	$5,275,990	$843,079	33.2
Change Alt B KBRA (.2)	-$935,176	-$125,722	-5.0	$0	$0	0.0	$0	-$125,722	-5.0	-$935,176	-$251,445	-9.9
Lower Klamath NWR - Alt B KBRA (.8)	$5,446,026	$732,148	28.9	$0	$0	0.0	$2,140,400	$732,148	28.9	$7,586,425	$1,464,296	57.7
Change Alt B KBRA (.8)	-$2,475,466	-$332,794	-13.1	$0	$0	0.0	$0	-$332,794	-13.1	-$2,475,466	-$665,589	-26.2
Lower Klamath NWR - Alt C (.2)	$1,375,259	$184,886	7.3	$0	$0	0.0	$2,140,400	$184,886	7.3	$3,515,659	$369,772	14.6
Change Alt C (.2)	$55,010	$7,395	0.3	$0	$0	0.0	$0	$7,395	0.3	$55,010	$14,791	0.6
Lower Klamath NWR - Alt C (.8)	$5,776,088	$776,520	30.6	$0	$0	0.0	$2,140,400	$776,520	30.6	$7,916,488	$1,553,041	61.2
Change Alt C (.8)	-$2,145,404	-$288,422	-11.4	$0	$0	0.0	$0	-$288,422	-11.4	-$2,145,404	-$576,844	-22.7
Lower Klamath NWR - Alt C KBRA (.2)	$3,135,591	$421,540	16.6	$0	$0	0.0	$2,140,400	$421,540	16.6	$5,275,990	$843,079	33.2
Change Alt C KBRA (.2)	-$935,176	-$125,722	-5.0	$0	$0	0.0	$0	-$125,722	-5.0	-$935,176	-$251,445	-9.9
Lower Klamath NWR - Alt C KBRA (.8)	$5,446,026	$732,148	28.9	$0	$0	0.0	$2,140,400	$732,148	28.9	$7,586,425	$1,464,296	57.7
Change Alt C KBRA (.8)	-$2,475,466	-$332,794	-13.1	$0	$0	0.0	$0	-$332,794	-13.1	-$2,475,466	-$665,589	-26.2
Lower Klamath NWR - Alt D (.2)	$1,375,259	$184,886	7.3	$0	$0	0.0	$2,140,400	$184,886	7.3	$3,515,659	$369,772	14.6
Change Alt D (.2)	$55,010	$7,395	0.3	$0	$0	0.0	$0	$7,395	0.3	$55,010	$14,791	0.6
Lower Klamath NWR - Alt D (.8)	$5,776,088	$776,520	30.6	$0	$0	0.0	$2,140,400	$776,520	30.6	$7,916,488	$1,553,041	61.2
Change Alt D (.8)	-$2,145,404	-$288,422	-11.4	$0	$0	0.0	$0	-$288,422	-11.4	-$2,145,404	-$576,844	-22.7
Lower Klamath NWR - Alt D KBRA (.2)	$3,465,653	$465,912	18.4	$0	$0	0.0	$2,140,400	$465,912	18.4	$5,606,052	$931,824	36.7
Change Alt D KBRA (.2)	-$605,114	-$81,350	-3.2	$0	$0	0.0	$0	-$81,350	-3.2	-$605,114	-$162,700	-6.4
Lower Klamath NWR - Alt D KBRA (.8)	$5,776,088	$776,520	30.6	$0	$0	0.0	$2,140,400	$776,520	30.6	$7,916,488	$1,553,041	61.2
Change Alt D KBRA (.8)	-$2,145,404	-$288,422	-11.4	$0	$0	0.0	$0	-$288,422	-11.4	-$2,145,404	-$576,844	-22.7
Tule Lake NWR- Alt A	$12,090,837	$1,625,457	64.1	$40,808,837	$9,118,266	446.7	$3,335,822	$1,625,457	64.1	$56,235,496	$12,369,179	574.8
Tule Lake NWR- Alt B	$10,123,006	$1,360,907	53.6	$38,375,928	$8,574,660	420.1	$5,858,366	$1,360,907	53.6	$54,357,300	$11,296,475	527.3
Change Alt B	-$1,967,831	-$264,549	-10.4	-$2,432,908	-$543,605	-26.6	$2,522,543	-$264,549	-10.4	-$1,878,196	-$1,072,704	-47.5
Tule Lake NWR- Alt C	$10,123,006	$1,360,907	53.6	$28,004,056	$6,257,184	306.5	$5,858,366	$1,360,907	53.6	$43,985,428	$8,978,999	413.8
Change Alt C	-$1,967,831	-$264,549	-10.4	-$12,804,781	-$2,861,081	-140.2	$2,522,543	-$264,549	-10.4	-$12,250,068	-$3,390,180	-161.0
Upper Klamath NWR - Alt A	$0	$0	0.0	$0	$0	0.0	$214,040	$0	0.0	$214,040	$0	0.0
Upper Klamath NWR - Alt B	$0	$0	0.0	$0	$0	0.0	$214,040	$0	0.0	$214,040	$0	0.0
Change Alt B	$0	$0	0.0	$0	$0	0.0	$0	$0	0.0	$0	$0	0.0
Clear Lake NWR - Alt A	$0	$0	0.0	$0	$0	0.0	$0	$0	0.0	$0	$0	0.0
Clear Lake NWR - Alt B	$0	$0	0.0	$0	$0	0.0	$0	$0	0.0	$0	$0	0.0
Change Alt B	$0	$0	0.0	$0	$0	0.0	$0	$0	0.0	$0	$0	0.0
Bear Valley NWR - No Agriculture	-	-	-	-	-	-	-	-	-	-	-	-

Source: IMPLAN input-output model run results.

Table 16: Regional economic benefits of Cattle Production: All Alternatives and Changes

Area (Alternative & Scenario)	Sales	Output	Employment Compensation	Jobs
Lower Klamath NWR [a]	$4,380,000	$7,269,804	$606,949	36.2
Lower Klamath NWR Alt C & D[a]	$5,431,200	$9,014,556	$752,617	44.9
Change Alt C & D	$1,051,200	$1,744,753	$145,668	8.7
Upper Klamath NWR (Low)	$613,200	$1,017,772	$84,973	5.1
Upper Klamath NWR (High)	$613,200	$1,017,772	$84,973	5.1
Clear Lake NWR	$602,250	$999,598	$83,456	5.0
Clear Lake NWR B	$963,600	$1,599,357	$133,529	8.0
Change Alt B	$361,350	$599,759	$50,073	3.0

Notes:
[a]For all water delivery schedules.

Table 17: Regional economic benefits of Lower Klamath NWR Budget Expenditures: All Alternatives and Changes

Category	Lower Klamath NWR Alt A[a]	Lower Klamath NWR Alt B[a]	Lower Klamath NWR Alt B Change	Lower Klamath NWR Alt C[a]	Lower Klamath NWR Alt C Change	Lower Klamath NWR Alt D[a]	Lower Klamath NWR Alt D Change
Salary Expenditures	*$1,364,508*	*$1,450,764*	*$86,256*	*$1,450,764*	*$86,256*	*$1,450,764*	*$86,256*
Salary Expenditures Less Benefits (used for calculations)	*$955,156*	*$1,015,535*	*$60,379*	*$1,015,535*	*$60,379*	*$1,015,535*	*$60,379*
Output	$1,953,976	$2,077,494	$123,518	$2,077,494	$123,518	$2,077,494	$123,518
Employment Compensation	$976,988	$1,038,747	$61,759	$1,038,747	$61,759	$1,038,747	$61,759
Jobs	13.6	14.5	0.9	14.5	0.9	14.5	0.9
All Other Expenditures[b]	*$404,461*	*$454,461*	*$50,000*	*$454,461*	*$50,000*	*$15,500,000*	*$15,095,539*
Output	$410,303	$461,025	$50,722	$461,025	$50,722	$15,723,872	$15,313,568
Employment Compensation	$102,839	$115,553	$12,713	$115,553	$12,713	$3,941,073	$3,838,234
Jobs	4.0	4.4	0.5	4.4	0.5	151.6	147.6
Total Budget	*$1,768,970*	*$1,905,225*	*$136,255*	*$1,905,225*	*$136,255*	*$16,950,764*	*$15,181,794*
Output	$2,364,279	$2,538,519	$174,240	$2,538,519	$174,240	$17,801,366	$15,437,087
Employment Compensation	$1,079,828	$1,154,300	$74,472	$1,154,300	$74,472	$4,979,820	$3,899,993
Jobs	17.6	19.0	1.4	19.0	1.4	166.1	148.5

Notes:

[a]For all water delivery schedules.

[b]65% of All Other Expenditures are local and used for the IMPLAN runs.

Table 18: Regional economic benefits of Clear Lake NWR Budget Expenditures: All Alternatives and Changes

Category	Clear Lake NWR	Clear Lake NWR Alt B	Clear Lake NWR Alt B Change
Salary Expenditures	*$303,224*	*$314,399*	*$11,175*
Salary Expenditures Less Benefits (used for calculations)	*$212,257*	*$220,079*	*$7,822*
Output	$303,951.84	$315,153.46	$11,202
Employment Compensation	$151,975.92	$157,576.73	$5,601
Jobs	2.1	2.2	0.1
All Other Expenditures[a]	*$89,880*	*$139,880*	*$50,000*
Output	$91,178.49	$141,900.33	$50,721.84
Employment Compensation	$22,853.22	$35,566.28	$12,713.06
Jobs	0.9	1.4	0.5
Total Budget	*$393,104*	*$454,279*	*$61,174*
Output	$395,130.33	$457,053.79	$61,923
Employment Compensation	$174,829.14	$193,143.01	$18,314
Jobs	3.0	3.6	0.6

Notes:
[a]65% of All Other Expenditures are local and used for the IMPLAN runs.

Table 19: Regional economic benefits of Tule Lake NWR Budget Expenditures: All Alternatives and Changes

Category	Tule Lake NWR	Tule Lake NWR Alt B	Tule Lake NWR Alt B Change	Tule Lake NWR Alt C	Tule Lake NWR Alt C Change
Salary Expenditures	*$1,061,284*	*$1,108,389*	*$47,105*	*$1,136,365*	*$75,081*
Salary Expenditures Less Benefits (used for calculations)	*$742,899*	*$776,426*	*$33,527*	*$797,943*	*$55,044*
Output	$1,519,759.12	$1,587,213.33	$67,454	$1,627,275.11	$107,516
Employment Compensation	$759,879.56	$793,606.67	$33,727	$813,637.55	$53,758
Jobs	10.6	11.1	0.5	11.4	0.8
All Other Expenditures[a]	*$314,581*	*$389,581*	*$75,000*	*$389,581*	*$75,000*
Output	$319,124.72	$395,207.97	$76,083	$395,207.97	$76,083
Employment Compensation	$79,986.27	$99,055.98	$19,070	$99,055.98	$19,070
Jobs	3.1	3.8	0.7	3.8	0.7
Total Budget	*$1,375,865*	*$1,497,970*	*$122,105*	*$1,525,946*	*$150,081*
Output	$1,838,883.84	$1,982,421.30	$143,537	$2,022,483.08	$183,599
Employment Compensation	$839,865.83	$892,662.65	$52,797	$912,693.54	$72,828
Jobs	13.7	14.9	1.2	15.2	1.5

Notes:
[a]65% of All Other Expenditures are local and used for the IMPLAN runs.

Table 20: Regional economic benefits of Bear Valley NWR Budget Expenditures: All Alternatives and Changes

Category	Bear Valley NWR	Bear Valley NWR Alt B	Bear Valley NWR Alt B Change
Salary Expenditures	*$151,612*	*$161,196*	*$9,584*
Salary Expenditures Less Benefits (used for calculations)	*$106,128*	*$113,114*	*$6,985*
Output	$217,108	$230,833	$13,724
Employment Compensation	$108,554	$115,416	$6,862
Jobs	1.5	1.6	0.1
All Other Expenditures[a]	*$44,940*	*$144,940*	*$100,000*
Output	$45,589	$147,033	$101,444
Employment Compensation	$11,427	$36,853	$25,426
Jobs	0.4	1.4	1.0
Total Budget	*$196,552*	*$306,136*	*$109,584*
Output	$262,698	$377,866	$115,168
Employment Compensation	$119,981	$152,269	$32,288
Jobs	2.0	3.0	1.1

Notes:
[a]65% of All Other Expenditures are local and used for the IMPLAN runs.

Table 21: Regional economic benefits of Upper Klamath NWR Budget Expenditures: All Alternatives and Changes

Category	Upper Klamath NWR	Upper Klamath NWR Alt B	Upper Klamath NWR Alt B Change
Salary Expenditures	*$160,138*	*$169,722*	*$9,584*
Salary Expenditures Less Benefits (used for calculations)	*$112,097*	*$119,082*	*$6,985*
Output	$229,318	$243,042	$13,724
Employment Compensation	$114,659	$121,521	$6,862
Jobs	1.6	1.7	0.1
All Other Expenditures[a]	*$44,940*	*$94,940*	*$50,000*
Output	$45,589	$96,311	$50,722
Employment Compensation	$11,427	$24,140	$12,713
Jobs	0.4	0.9	0.5
Total Budget	*$205,078*	*$264,662*	*$59,584*
Output	$274,907	$339,353	$64,446
Employment Compensation	$126,085	$145,661	$19,575
Jobs	2.0	2.6	0.6

Notes:
[a]65% of All Other Expenditures are local and used for the IMPLAN runs.

Table 22. Summary of Recreation by Refuge and Alternative: Visitation Data

Area Alternative, Recreation Category	Local Residents (Visits per year)	Non-Local Residents (Visits per year)	Total (Visits per year)	Average Recreation Time (hours per visit)	Visitor Hours	Visitor Days
Bear Valley Alt A, Hunting	245	35	280	10	2,800	350
Bear Valley Alt A, Non-Consumptive	0	0	0	0	0	0
Bear Valley Alt B, Hunting	245	70	315	10	3,150	394
Bear Valley Alt B, Non-Consumptive	175	475	650	4	2,375	297
Clear Lake Alt A, Hunting	25	50	75	10	750	94
Clear Lake Alt A, Non-Consumptive	0	0	0	0	0	0
Clear Lake Alt B, Hunting	25	50	75	10	750	94
Clear Lake Alt B, Non-Consumptive	200	200	400	4	1,600	200
Lower Klamath Alt A (.2), Hunting	3,500	4,500	8,000	5	40,000	5,000
Lower Klamath Alt A (.2), Non-Consumptive	11,150	16,150	27,300	3	94,200	11,775
Lower Klamath Alt A (.8), Hunting	5,500	6,500	12,000	5	60,000	7,500
Lower Klamath Alt A (.8), Non-Consumptive	13,650	18,650	32,300	4	129,200	16,150
Lower Klamath Alt A (KBRA), Hunting	7,500	8,500	16,000	5	80,000	10,000
Lower Klamath Alt A (KBRA), Non-Consumptive	14,650	21,150	35,800	4	143,200	17,900
Lower Klamath Alt B (.2), Hunting	3,900	4,900	8,800	5	44,000	5,500
Lower Klamath Alt B (.2), Non-Consumptive	15,840	20,840	36,680	5	169,080	21,135
Lower Klamath Alt B (.8), Hunting	5,900	6,900	12,800	5	64,000	8,000
Lower Klamath Alt B (.8), Non-Consumptive	18,340	23,340	41,680	5	206,080	25,760
Lower Klamath Alt B (KBRA), Hunting	7,900	8,900	16,800	5	84,000	10,500
Lower Klamath Alt B (KBRA), Non-Consumptive	19,340	25,840	45,180	5	220,080	27,510
Lower Klamath Alt C (.2), Hunting	3,900	4,900	8,800	5	44,000	5,500
Lower Klamath Alt C (.2), Non-Consumptive	15,840	20,840	36,680	5	169,080	21,135
Lower Klamath Alt C (.8), Hunting	5,900	6,900	12,800	5	64,000	8,000
Lower Klamath Alt C (.8), Non-Consumptive	18,340	23,340	41,680	5	206,080	25,760
Lower Klamath Alt C (KBRA), Hunting	7,900	8,900	16,800	5	84,000	10,500
Lower Klamath Alt C (KBRA), Non-Consumptive	19,340	25,840	45,180	5	220,080	27,510
Lower Klamath Alt D (.2), Hunting	3,400	4,400	7,800	5	39,000	4,875
Lower Klamath Alt D (.2), Non-Consumptive	15,840	20,840	36,680	5	169,080	21,135
Lower Klamath Alt D (.8), Hunting	5,400	6,400	11,800	5	59,000	7,375
Lower Klamath Alt D (.8), Non-Consumptive	18,340	23,340	41,680	5	206,080	25,760
Lower Klamath Alt D (KBRA), Hunting	7,400	8,400	15,800	5	79,000	9,875
Lower Klamath Alt D (KBRA), Non-Consumptive	19,340	25,840	45,180	5	220,080	27,510
Tule Lake Alt A, Hunting	6,250	7,500	13,750	12	165,000	20,625
Tule Lake Alt A, Non-Consumptive	16,150	24,150	40,300	5	201,500	25,188
Tule Lake Alt B, Hunting	6,750	8,100	14,800	12	177,600	22,200
Tule Lake Alt B, Non-Consumptive	19,840	27,840	47,680	6	305,760	38,220
Tule Lake Alt C, Hunting	6,750	8,100	14,800	12	177,600	22,200
Tule Lake Alt C, Non-Consumptive	19,840	27,840	47,680	6	305,760	38,220
Upper Klamath Alt A, Fishing	3,000	2,000	5,000	10	50,000	6,250
Upper Klamath Alt A, Hunting	1,000	3,000	4,000	12	48,000	6,000
Upper Klamath Alt A, Non-Consumptive	2,000	8,000	10,000	5	50,000	6,250
Upper Klamath Alt B, Fishing	3,000	2,000	5,000	10	50,000	6,250
Upper Klamath Alt B, Hunting	1,000	3,000	4,000	12	48,000	6,000
Upper Klamath Alt B, Non-Consumptive	2,700	10,800	13,500	6	81,000	10,125

Table 23. Summary of Recreation by Refuge and Alternative: Expenditures and Economic Effects

Area Alternative, Recreation Category	Recreation Expenditures (1,000 2015 Dollars)		Local Residents Expenditure Multiplier			Non-Local Residents Expenditure Multiplier			Local and Non-Local Residents Economic Effect		
	Residents	Non-Residents	Output	Employment Compensation	Jobs (Per Million Expenditures)	Output	Employment Compensation	Jobs (Per Million Expenditures)	Output ($1,000 2015)	Employment Compensation ($1,000 2015)	Total Jobs
Bear Valley Alt A	35	4	1.54	0.32	11.83	1.51	0.30	-	60	12	-
Bear Valley Alt B	39	44	1.54	0.32	11.83	1.51	0.30	-	127	26	-
Clear Lake Alt A	4	6	1.58	0.35	15.51	1.53	0.32	-	15	3	-
Clear Lake Alt B	9	20	1.58	0.35	15.51	1.53	0.32	-	45	10	-
Lower Klamath Alt A (.2)	381	1,273	1.58	0.35	14.98	1.54	0.33	13.02	2,562	555	22.29
Lower Klamath Alt A (.8)	543	1,764	1.58	0.35	14.98	1.54	0.33	13.02	3,575	775	31.12
Lower Klamath Alt A (KBRA)	625	2,082	1.58	0.35	14.98	1.54	0.33	13.02	4,194	909	36.49
Lower Klamath Alt B (.2)	759	2,191	1.58	0.35	14.98	1.54	0.33	13.02	4,572	991	39.90
Lower Klamath Alt B (.8)	834	2,461	1.58	0.35	14.98	1.54	0.33	13.02	5,108	1,107	44.55
Lower Klamath Alt B (KBRA)	916	2,779	1.58	0.35	14.98	1.54	0.33	13.02	5,726	1,241	49.92
Lower Klamath Alt C (.2)	759	2,191	1.58	0.35	14.98	1.54	0.33	13.02	4,572	991	39.90
Lower Klamath Alt C (.8)	759	2,191	1.58	0.35	14.98	1.54	0.33	13.02	4,572	991	39.90
Lower Klamath Alt C (KBRA)	759	2,191	1.58	0.35	14.98	1.54	0.33	13.02	4,572	991	39.90
Lower Klamath Alt D (.2)	759	2,191	1.58	0.35	14.98	1.54	0.33	13.02	4,572	991	39.90
Lower Klamath Alt D (.8)	759	2,191	1.58	0.35	14.98	1.54	0.33	13.02	4,572	991	39.90
Lower Klamath Alt D (KBRA)	759	2,191	1.58	0.35	14.98	1.54	0.33	13.02	4,572	991	39.90
Tule Lake Alt A	853	2,962	1.57	0.35	15.14	1.54	0.33	13.50	5,916	1,283	52.90
Tule Lake Alt B	1,009	3,352	1.57	0.35	15.14	1.54	0.33	13.50	6,762	1,466	60.52
Tule Lake Alt C	1,009	3,352	1.57	0.35	15.14	1.54	0.33	13.50	6,762	1,466	60.52
Upper Klamath Alt A	337	1,383	1.59	0.36	15.60	1.55	0.33	13.60	2,675	581	24.07
Upper Klamath Alt B	362	1,627	1.59	0.36	15.60	1.55	0.33	13.60	3,091	671	27.78

References

Printed References

Maillett, Edward. 2011. Refuge recreation economics technical report for the secretarial determination on whether to remove four dams on the Klamath River in California and Oregon. U.S. Fish and Wildlife Service Division of Economics. Washington DC. September 13, 2011.

Mauser, David and Tim Mayer. 2011. Effects of the Klamath Basin Restoration Agreement to Lower Klamath, Tule Lake, and Upper Klamath National Wildlife Refuges. U.S. Fish and Wildlife Service. Tulelake, CA.

Minnesota IMPLAN Group, Inc. 2012 and 2016 runs. 2010 and 2013 IMPLAN data files for study area counties. Stillwater, MN.

U.S. Census Bureau. 2010. Census data compiled for the study area. Washington DC.

U.S. Department of Agriculture, National Agricultural Statistics Service (USDA NASS). 2012 Census Volume 1, Chapter 1: U.S. National Level Data. Table 13. Cattle and Calves – Sales: 2012 and 2007 https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_US/st99_1_012_013.pdf

Personal Communications

Barry, Michelle. Conservation Planner, Klamath Basin National Wildlife Refuge Complex, Tulelake, CA. E-mail and telephone communications with Thomas Wegge, TCW Economics, transmitting budget data, agricultural acreage, and related information for the refuge complex and management alternatives. January 29, January 30, February 4, February 20, February 25, and March 8, 2013.

Freitas, Stacy. Wildlife Refuge Specialist. Klamath Basin National Wildlife Refuge Complex, Tulelake, CA. E-mail communications with Mark Pelz, transmitting hunting data. April 18, 2016.

Green, Mike. Senior Natural Resource Specialist; Leaselands, Crops & IPM; Bureau of Reclamation; Klamath Basin Area Office. E-mail communications with Mark Pelz, transmitting Land lease data, Kuchel Act PILT Payments. April 21,2016.

Griggs, Kenneth. Deputy Project Leader. Klamath Basin National Wildlife Refuge Complex, Tulelake, CA. E-mail and telephone communications with Iris Maska, USFWS Division of Economics, transmitting budget data, and projected refuge visitation. April 18 and April 27, 2016.

Pelz, Mark. Chief, Natural Resources Division. U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, CA. E-mail and telephone communications with Iris Maska, USFWS Division of Economics, transmitting agricultural data. April 18, and April 27, 2016.

Smith, Richard. Land Acq. Planner, U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, CA. E-mail communications with Mark Pelz, transmitting grazing data. April 21, 2016.

Taylor, Viola. Realty Specialist, Region 8 Realty Office, U.S. Fish and Wildlife Service. RSS payment data. E-mail communications with Mark Pelz, transmitting RSS data. April 14, 2016.

Appendix Q – Klamath Basin National Wildlife Refuge Complex Integrated Pest Management Program

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Appendix Q – Integrated Pest Management Program

1.0 Background

IPM is an interdisciplinary approach utilizing methods to prevent, eliminate, contain, and/or control pest species in concert with other management activities on refuge lands and waters to achieve wildlife and habitat management goals and objectives. IPM is also a scientifically based, adaptive management process (see 43 C.F.R. 46.145) where available scientific information and best professional judgment of the refuge staff as well as other resource experts are used to identify and implement appropriate management strategies that can be modified and/or changed over time to ensure effective, site-specific management of pest species. Considering refuge resource objectives and the ecology of pest species, a tolerable pest population (threshold) is established and one or more pest management methods, or combinations thereof, is selected that is feasible, efficacious, and most protective of non-target resources (including native fish, wildlife, and plants), Service personnel, Service authorized agents, volunteers, and the public. Staff time and available funding are considered when determining feasibility/practicality of various treatments.

IPM techniques to address pests are presented as CCP strategies (see Appendix F) to achieve refuge resource objectives. Consistent with Service policy, the following IPM program elements have been incorporated into this CCP (see the Service Director's September 9, 2004 memo titled *Integrated Pest Management Plans and Pesticide Use Proposals: Updates, Guidance, and an Online Database*):

- Habitat and/or wildlife objectives that identify pest species and appropriate thresholds to indicate the need for and successful implementation of IPM techniques; and
- Monitoring before and/or after treatment to assess progress toward achieving objectives including pest thresholds.

Where pesticides are determined necessary to manage pests, this Appendix provides a structured procedure to evaluate potential effects of ground-based applications to refuge biological resources and environmental quality. Only pesticide uses that, with appropriate BMPs (as identified through the PUP process), would likely cause minor, temporary, or localized effects to refuge biological resources and environmental quality would be allowed for use on the refuges.

This Appendix does not describe the more detailed process to evaluate potential effects associated with aerial applications of pesticides. However, the basic framework to assess potential effects to refuge biological resources and environmental quality from aerial application of pesticides or use of insecticides for mosquito management would be similar to the process described in this Appendix for ground-based pesticide treatments.

2.0 Pest Management Laws and Policies

Service policy states that plant, invertebrate, and vertebrate pests on units of the National Wildlife Refuge System can be controlled to ensure balanced wildlife and fish populations in support of refuge-specific wildlife and habitat management objectives (see 569 FW 1, Integrated Pest Management). Pest control on Federal (refuge) lands and waters also is authorized under the following Federal statutes and executive orders:

- National Wildlife Refuge System Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee);
- Plant Protection Act of 2000 (7 U.S.C. 7701 *et seq*.);
- Noxious Weed Control and Eradication Act of 2004 (7 U.S.C. 7781-7786, Subtitle E);
- Federal Insecticide, Fungicide, and Rodenticide Act of 1996 (7 U.S.C. 136-136y);
- National Invasive Species Act of 1996 (16 U.S.C. 4701);
- Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (16 U.S.C. 4701);
- Food Quality Protection Act of 1996 (7 U.S.C. 136);
- Executive Order 13148, Section 601(a);
- Executive Order 13112; and
- Animal Damage Control Act of 1931 (7 U.S.C. 426-426c, 46 Stat. 1468).

U.S. Department of the Interior policy defines pests as "…living organisms that may interfere with the site-specific purposes, operations, or management objectives or that jeopardize human health or safety" (see 517 DM 1, Integrated Pest Management Policy). Similarly, Service policy defines pests as "…invasive plants and introduced or native organisms, that may interfere with achieving our management goals and objectives on or off our lands, or that jeopardize human health or safety" (see 569 FW 1, Integrated Pest Management). U.S. Department of the Interior policy also defines an invasive species as "a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health" (517 DM 1) Throughout this CCP, the terms pest and invasive species are used interchangeably because both can prevent/impede achievement of refuge wildlife and habitat objectives and/or degrade environmental quality.

In general, control of pests (vertebrate or invertebrate) on the refuges would conserve and protect the Nation's fish, wildlife, and plant resources as well as safeguard environmental quality. Service policy also states that animal or plant species which are considered pests may be managed if the following criteria are met (569 FW 1):

- The pest causes a threat to human or wildlife health or private property, the acceptable level of damage by the pest has been exceeded, or Federal, state, or local governments have designated the pest as noxious;
- The pest is detrimental to a refuge resource management goal or objective; and
- Pest control would not interfere with achieving of site management goals and objectives or the purposes for which a refuge was established.

The specific justifications for pest management activities on a refuge are the following:

- Protect human health and well-being;
- Prevent substantial damage to important refuge resources;

- Protect newly introduced or re-established native species;
- Control non-native (exotic) species in order to support populations of native species;
- Prevent damage to private property; and
- Provide the public with quality, compatible wildlife-dependent recreational opportunities.

Service policy for habitat management plans provides the following additional guidance regarding management of invasive species on a refuge (see 620 FW 1, Habitat Management Plans):

- "We are prohibited by Executive Order, law, and policy from authorizing, funding, or carrying out actions that are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere."
- "Manage invasive species to improve or stabilize biotic communities to minimize unacceptable change to ecosystem structure and function and prevent new and expanded infestations of invasive species. Conduct refuge habitat management activities to prevent, control, or eradicate invasive species..."

Federal regulations describe how animal species that are damaging/destroying federal property and/or detrimental to the management program of a refuge may be controlled (see 50 C.F.R. 31.14, Official Animal Control Operations)**.** For example, the incidental removal of a beaver that is damaging refuge infrastructure (e.g., clogging a water control structure) and/or negatively affecting habitat (e.g., removing woody species from existing or restored riparian habitat) may occur without a pest control proposal. We recognize beavers are native species and most of their activities on refuge lands represent a natural process beneficial for maintaining wetland habitats. Exotic nutria, whose denning and burrowing activities in wetland dikes causes cave-ins and breaches, can be controlled using the most effective techniques considering site-specific factors without a pest control proposal. Along with the loss of quality wetland habitats associated with breaching of impoundments, the safety of refuge staffs and the public (e.g., on auto tour routes) driving on structurally compromised levees and dikes can be threatened by sudden and unexpected cave-ins.

Trespass and feral animals may also be controlled on refuge lands. **D**ogs and cats running at large on a national wildlife refuge and observed in the act of killing, injuring, harassing, or molesting humans or wildlife may be disposed of in the interest of public safety and protection of wildlife (see 50 C.F.R. 28.43, Destruction of Dogs and Cats). Feral animals should be disposed of by the most humane method(s) available and in accordance with relevant Service directives and Executive Order 11643. Wildlife specimens may be donated or loaned to public institutions; however, donation or loan of resident wildlife species will only be made after securing state approval (see 50 C.F.R. 30.11, Donation and Loan of Wildlife Specimens**).** Surplus wildlife specimens may be sold alive or butchered, dressed and processed subject to Federal and state laws and regulations (50 C.F.R. 30.12, Sale of Wildlife Specimens**).**

3.0 Strategies

To fully embrace IPM, the following strategies, where applicable, would be carefully considered on the refuge for each pest species (569 FW 1):

- **Prevention.** This is the most effective and least expensive long-term management option for pests. It encompasses methods to prevent new introductions or the spread of established pests to un-infested areas. It requires identifying potential routes of invasion to reduce the likelihood of infestation. In order to identify appropriate BMPs for prevention, Hazard Analysis and Critical Control Points (HACCP) planning can be used to determine if current management activities on a refuge may introduce and/or spread invasive species. See http://www.haccp-nrm.org/ for more information about HACCP planning.

  Prevention may include source reduction, using pathogen-free or weed-free seeds or fill; exclusion methods (e.g., barriers) and/or sanitation methods (e.g., wash stations) to prevent re-introductions by various mechanisms including vehicles, personnel, livestock, and horses. Because invasive species are frequently the first to establish in newly disturbed sites, prevention requires a reporting mechanism for early detection of new pest occurrences. A quick response can then be mounted to eliminate any new satellite pest populations. Prevention requires consideration of the scale and scope of land management activities that may promote pest establishment within un-infested areas or promote reproduction and spread of existing populations. Along with preventing initial introduction, prevention involves halting the spread of existing infestations to new sites (Mullin et al. 2000). The primary reason for prevention is to keep pest-free lands or waters from becoming infested. Executive Order 11312 emphasizes the priority for prevention with respect to managing pests.

  Following are methods to prevent the introduction and/or spread of pests on refuge lands (USFS, 2005).
  - Before beginning ground-disturbing activities (e.g., disking or scraping), inventory and prioritize pest infestations in project operating areas and along access routes. Identify pest species on-site or in the vicinity of a reasonably expected potential invasion. Where possible, begin project activities in un-infested areas before working in pest-infested areas.
  - Use pest-free project staging areas. Avoid or minimize travel through pest-infested areas or restrict travel to those periods when spread of seeds or propagules of invasive plants is least likely.
  - When appropriate, identify sanitation sites where equipment can be cleaned of pests. Where possible, clean equipment before entering lands at on-refuge approved cleaning site(s). This practice does not pertain to vehicles traveling frequently in and out of the project area that will remain on roadways. Where practical, collect seeds and plant parts of pest plants. Remove mud, dirt, and plant parts from project equipment before moving it into a project area.
  - If operating in areas infested with pests, clean all equipment before leaving the project site.
  - Where possible, refuge staffs, authorized agents, and volunteers need to inspect, remove, and properly dispose of invasive plant seeds and parts found on their clothing and equipment. Proper disposal means bagging the seeds and plant parts and then properly discarding of them (e.g., through incineration).
  - Evaluate options, including closure, to restrict traffic on sites with on-going restoration of desired vegetation. Revegetate disturbed soil (except travel ways on surfaced projects) to optimize plant establishment for each specific site. As necessary, revegetation may include topsoil replacement, planting, seeding, fertilization, liming, and weed-free mulching. Use native plant materials, where appropriate and feasible.

Where they are reasonably available, use certified weed-free or weed-seed-free hay or straw.

- Provide information, training, and appropriate pest identification materials to permit holders and recreational visitors. Educate them about pest identification, biology, impacts, and effective prevention measures.
- Require grazing permittees to utilize preventative measures for their livestock while on refuge lands.
- Inspect borrow material for invasive plants prior to use and transport onto and/or within refuge lands.
- Consider invasive plants in planning for road maintenance activities.
- Restrict off-road travel to designated routes.

Following are methods to prevent the introduction and/or spread of pests into refuge waters (USFS, 2005).

- Inspect boats (including air boats), trailers, and other boating equipment. Remove any visible plants, animals, or mud before leaving any waters or boat launching facilities. Drain water from motor, live well, bilge, and transom wells while on land before leaving the site. If possible, wash and dry boats, downriggers, anchors, nets, floors of boats, propellers, axles, trailers, and other boating equipment to kill pests not visible at the boat launch.
- Maintain an l00-foot buffer of aquatic pest-free clearance around boat launches and docks or quarantine areas when cleaning around culverts, canals, or irrigation sites. Inspect and clean equipment before moving to new sites or from one project area to another.

- **Mechanical/Physical Methods.** These methods remove and destroy, disrupt the growth of, or interfere with the reproduction of pest species. For plants species, these treatments can be accomplished by hand, hand tool (manual), or power tools (mechanical), and include pulling, grubbing, digging, tilling/disking, cutting, swathing, grinding, sheering, girdling, mowing, and mulching of the pest plants. Thermal techniques such as steaming, super-heated water, and hot foam may also be viable treatments.

  For animal species, mechanical/physical methods (including trapping) can be used to control pests as a refuge management activity. Federal regulations state that trapping can be used on a refuge to reduce surplus wildlife populations for a "balanced conservation program," in accordance with Federal or state laws and regulations (see 50 C.F.R. 31.2). In some cases, non-lethally trapped animals can be relocated to off-refuge sites with prior approval from the state.

  Each of these tools can be efficacious to some degree and applicable to specific situations. In general, mechanical controls can effectively control annual and biennial pest plants. However, to control perennial plants, the root system has to be destroyed or it resprouts and continues to grow and develop. Mechanical controls are typically not capable of destroying a perennial plant's root system. Although some mechanical tools (e.g., disking, plowing) may damage root systems, they may stimulate regrowth producing a denser plant population that may aid in the spread depending upon the target species (e.g., Canada thistle). In addition, steep terrain and soil conditions can be major factors that limit the use of many mechanical control methods.

Some mechanical control methods (e.g., mowing), which can be used in combination with herbicides, can be a very effective technique to control perennial species. For example, mowing perennial plants followed sequentially by treating the plant regrowth with a systemic herbicide often improves the efficacy of the herbicide compared to herbicide treatment only.

- **Cultural Methods.** These methods involve manipulating habitat to increase pest mortality by reducing its suitability to the pest. Cultural methods include water-level manipulation, mulching, winter cover crops, changing planting dates to minimize pest impact, prescribed burning (to facilitate revegetation, increase herbicide efficacy, and remove litter to assist in emergence of desirable species), flaming with propane torches, trap crops, crop rotations (including non-susceptible crops), moisture management, addition of beneficial insect habitat, reducing clutter, proper trash disposal, planting or seeding desirable species to shade or out-compete invasive plants, applying fertilizer to enhance desirable vegetation, prescriptive grazing, and other habitat alterations.

- **Biological Control Agents.** Classical biological control involves the deliberate introduction and management of natural enemies (parasites, predators, or pathogens) to reduce pest populations. Many of the most ecologically or economically damaging pest species in the United States originated in foreign countries. These newly introduced pests, which are free from natural enemies found in their country or region of origin, may have a competitive advantage over cultivated and native species. This competitive advantage often allows introduced species to flourish, and they may cause widespread economic damage to crops or out compete and displace native vegetation. Once the introduced pest species population reaches a certain level, traditional methods of pest management may be cost prohibitive or impractical. Biological controls typically are used when pest populations have become so widespread that eradication or effective control is difficult or no longer practical.

  Biological control has advantages as well as disadvantages. Benefits include reducing pesticide usage, host specificity for target pests, long-term self-perpetuating control, low cost/acre, capacity for searching and locating hosts, synchronizing biological control agents to hosts' life cycles, and the unlikelihood that hosts will develop resistance to agents. Disadvantages include limited availability of agents from their native lands, dependence of control on target species density, slow rate at which control occurs, biotype matching, the difficulty and expense of conflicts over control of the target pest, and host specificity when host populations are low.

  A reduction in target species populations from biological controls is typically a slow process, and efficacy can be highly variable. It may not work well in a particular area, although it works well in other areas. Biological control agents require specific environmental conditions to survive over time. Some of these conditions are understood; whereas, others are only partially understood or not understood at all.

  Biological control agents do not eradicate a target pest. When using biological control agents, residual levels of the target pest typically are expected; the agent population level or survival is dependent upon the density of its host. After the pest population decreases, the population of the biological control agent decreases correspondingly. This is a natural cycle. Some pest populations (e.g., invasive plants) tend to persist for several years after a biological control agent becomes established due to seed reserves in the soil, inefficiencies in the agents' search behavior, and the natural lag in population buildup of the agent.

The full range of pest groups potentially found on refuge lands and waters includes diseases, invertebrates (e.g., insects and mollusks), vertebrates, and invasive plants (the most common group). Often it is assumed that biological control can address many if not most of these pest problems. There are several well-documented success stories of biological control of invasive weed species in the Pacific Northwest including Mediterranean sage, St. Johnswort (Klamath weed), and tansy ragwort. Emerging success stories include Dalmatian toadflax, diffuse knapweed, leafy spurge, purple loosestrife, and yellow star thistle. However, historically, each new introduction of a biological control agent in the United States has only about a 30% success rate (Coombs et al., 2004).

Introduced species without desirable close relatives in the United States are generally selected as biological controls. Natural enemies that are restricted to one or a few closely related plants in their country of origin are targeted as biological controls (Center et al., 1997; Hasan and Ayres, 1990).

Introduced agents must be approved by the applicable authorities. Except for a small number of formulated biological control products registered by USEPA under FIFRA, most biological control agents are regulated by the U.S. Department of Agriculture (USDA)-Animal Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPQ). State departments of agriculture and, in some cases, county agricultural commissioners or weed districts, have additional approval authority.

Federal permits (USDA-APHIS-PPQ Form 526) are required to import biocontrols agents from another state. Form 526 may be obtained from USDA-APHIS-PPQ (Biological Assessment and Taxonomic Support, 4700 River Road, Unit 113, Riverdale, MD 20737) or online at http://www.aphis.usda.gov/ppq/permits/bioligical/weedbio.html.

The Service strongly supports the development, and legal and responsible use of appropriate, safe, and effective biological control agents for nuisance and non-indigenous or pest species.

State and county agriculture departments may also be sources for biological control agents or they may have information about where biological control agents may be obtained. Commercial sources should have an Application and Permit to Move Live Plant Pests and Noxious Weeds (USDA-PPQ Form 226 from USDA-APHIS-PPQ, Biological Assessment and Taxonomic Support, 4700 River Road, Unit 113, Riverdale, MD 20737) to release specific biological control agents in a state and/or county. Furthermore, certification regarding the biological control agent's identity (genus, specific epithet, sub-species and variety) and purity (e.g., parasite free, pathogen free, and biotic and abiotic contaminants) should be specified in purchase orders.

Use of biological control agents on refuges is subject to Service policy on Exotic Species Introduction and Management (see 7 RM 8). In addition, the refuge staff should follow the International Code of Best Practice for Classical Biological Control of Weeds (http://sric.ucdavis.edu/exotic /exotic.htm) as ratified by delegates to the X International

Symposium on Biological Control of Weeds, Bozeman, MT, July 9, 1999. This code identifies the following:

- Release only approved biological control agents,
- Use the most effective agents,
- Document releases, and
- Monitor for impact to the target pest, non-target species and the environment.

Biological control agents formulated as pesticide products and registered by the USEPA (e.g., *Bti*) are also subject to PUP review and approval (see below).

A record of all releases should be maintained with date(s), location(s), and environmental conditions of the release site(s); the identity, quantity, and condition of the biological control agents released; and other relevant data and comments such as weather conditions. Systematic monitoring to determine the establishment and effectiveness of the release is also recommended.

NEPA documents regarding biological and other environmental effects of biological control agents prepared by another Federal agency, where the scope is relevant to evaluation of releases on refuge lands, should be reviewed and, as appropriate, adopted for Service use. Possible source agencies for such NEPA documents include the U.S. Bureau of Land Management, U.S. Forest Service, U.S. National Park Service, U.S. Department of Agriculture-Animal and Plant Health Inspection Service, and the U.S. military services. It can be appropriate to summarize and incorporate through reference parts or all of relevant documents. Incorporating by reference (43 CFR 46.135) is a technique used to avoid redundancies in analyses. It can reduce the bulk of a Service NEPA document

- **Pesticides.** The selective use of pesticides is based upon pest ecology (including mode of reproduction), the size and distribution of its populations, site-specific conditions (e.g., soils and topography), known efficacy under similar site conditions, and the capability to utilize best management practices (BMPs) to reduce/eliminate potential effects to non-target species, sensitive habitats, and potential to contaminate surface and groundwater. All pesticide usage (including pesticide, target species, application rate, and method of application) must comply with the applicable federal (FIFRA) and state regulations pertaining to pesticide use, safety, storage, disposal, and reporting. Before pesticides can be used to eradicate, control, or contain pests on refuge lands and waters, pesticide use proposals (PUPs) are prepared and approved consistent with Service policy (569 FW 1). PUP records provide a detailed, time-, site-, and target-specific description of the proposed use of pesticides on the refuge. All PUPs are created, approved, approved with modification, or disapproved, and stored in the Pesticide Use Proposal System (PUPS), which is a centralized database accessible on the Service's intranet (https://systems.fws.gov/pups). Only Service employees are authorized to access PUP records through this database.

  Application equipment is selected to provide site-specific delivery to target pests while minimizing/eliminating direct or indirect (e.g., drift) exposure to non-target areas and degradation of surface and groundwater quality. Where possible, target-specific equipment (e.g., backpack sprayer or wiper) is used to treat target pests. Other target-specific equipment to apply pesticides includes soaked wicks or paint brushes for wiping vegetation and lances, hatchets, or syringes for direct injection into stems. Granular pesticides can be applied using seeders or other specialized dispensers. In contrast, aerial spraying (e.g., fixed wing or helicopter) is only be used where access is difficult (remoteness) and/or the size/distribution of infestations precludes practical use of ground-based methods.

Because repeated use of one pesticide may allow resistant organisms to survive and reproduce, multiple pesticides with variable modes of action are considered for treatments on refuge lands and waters. This is especially important if multiple applications within years and/or over a growing season are likely to be necessary for habitat maintenance and restoration activities to achieve resource objectives. Integrated chemical and non-chemical controls also are highly effective, where practical, because pesticide-resistant organisms can be removed from the site.

Cost is not being the primary factor in selecting a pesticide for use on a refuge. If the least expensive pesticide would potentially harm natural resources or people, then a different product is selected, if available. The most efficacious pesticide available with the least potential to degrade environmental quality (i.e., soils, surface water, and groundwater) and the least potential to affect native species and communities of fish, wildlife, plants, and their habitats would be acceptable for use on refuge lands in the context of an IPM approach.

- **Habitat restoration/maintenance.** Restoration and/or proper maintenance of refuge habitats associated with achieving wildlife and habitat objectives is essential for long-term prevention, eradication, or control (at or below threshold levels) of pests. Promoting desirable plant communities through the manipulation of species composition, plant density, and growth rate is an essential component of invasive plant management (Masters et al. 1996, Masters and Shelly 2001, Brooks et al. 2004). The following three components of succession can be manipulated through habitat maintenance and restoration: site availability, species availability, and species performance (Cox and Anderson 2004). Although a single method (e.g., herbicide treatment) may eliminate or suppress pest species in the short term, the resulting gaps and bare soil create niches that can be conducive to further invasion by the species and/or other invasive plants. On degraded sites where desirable species are absent or in low abundance, revegetation with native/desirable grasses, forbs, and legumes may be necessary to direct and accelerate plant community recovery, and achieve site-specific objectives in a reasonable time frame. The selection of appropriate species for revegetation is dependent on a number of factors including resource objectives and site-specific, abiotic factors (e.g., soil texture, precipitation/temperature regimes, and shade conditions). Seed availability and cost, ease of establishment, seed production, and competitive ability also are important considerations.

4.0 Priorities for Treatments

For many refuges, the magnitude of pest problems (i.e., the number, distribution, and sizes of infestations) is too extensive and beyond the available capital resources to effectively address during any single field season. To manage pests on the refuge, it is essential to prioritize treatment of infestations. Highest priority treatments are focused on early detection and rapid response to eliminate infestations of new pests. It is especially important for restoration and maintenance of biological integrity, diversity, and environmental health to target aggressive pests that may impact species, species groups, communities, and/or habitats associated refuge purpose(s), NWRS resources of concern (i.e., federally listed species, migratory birds, selected marine mammals, and interjurisdictional fish), and native species.

The next priority is treating established pests that appear in one or more previously un-infested areas. Moody and Mack (1988) demonstrated through modeling that small, new outbreaks of invasive plants eventually infest an area larger than the established, source population. They also found that control efforts focusing on the large, main infestation rather than the new, small satellites reduced the chances of overall success. The lowest priority is treating large infestations (sometimes monotypic stands) of well-established pests. In this case, initial efforts focus upon containment of the perimeter followed by work to control/eradicate the established infested area. If containment and/or control of a large infestation is not effective, then efforts refocus upon halting pest reproduction or managing source populations. Maxwell et al. (2009) found treating fewer populations that are sources represents an effective long-term strategy to reduce the total number of invasive populations and decrease meta-population growth rates.

Although state-listed noxious weeds are always of high priority for management, other pest species known to cause substantial ecological impact are also considered for priority treatment. For example, cheatgrass may not be listed by a state as noxious, but it can greatly alter fire regimes in shrub steppe habitats (like at Clear Lake NWR), eventually establishing large monotypic stands that displace native bunch grasses, forbs, and shrubs. Pest control requires a multi-year commitment. Essential to the long-term success of pest management is pre- and post-treatment monitoring, assessment of the successes and failures of treatments, and development of new approaches when proposed methods do not achieve desired outcomes.

5.0 Best Management Practices (BMPs)

BMPs can minimize or eliminate potential pesticide effects to non-target species and/or sensitive habitats, as well as degradation of water quality from drift, surface runoff, or leaching. Based upon the Department of Interior Pesticide Use Policy (517 DM 1) and the Service Integrated Pest Management policy (569 FW 1), the use of applicable BMPs (where feasible) help ensure that pesticide uses do not adversely affect federally listed species and/or their critical habitats through determinations made using the consultation process described in Federal regulations (50 C.F.R. part 402).

Following are BMPs for mixing/handling and applying pesticides for all ground-based pesticide treatments of pesticides. Although not listed below, the most important BMP to eliminate/reduce potential impacts to non-target resources is an IPM approach to prevent, control, eradicate, and contain pests.

5.1 Pesticide Handling and Mixing

- As a precaution against spilling, spray tanks should not be left unattended during filling.
- All pesticide containers should be triple rinsed and the rinsate would be used as water in the sprayer tank and applied to treatment areas.
- All pesticide spray equipment should be properly cleaned. Where possible, rinsate should be used as part of the make-up water in the sprayer tank and applied to treatment areas.

- Pesticide containers should be triple rinsed and recycled (where feasible).
- All unused pesticides should be properly discarded at a local "safe send" collection site.
- Pesticides and pesticide containers should be lawfully stored, handled, and disposed of in accordance with the label and in a manner safeguarding human health, fish, and wildlife, soil and water.
- Where specified on the pesticide label, water quality parameters (e.g., pH and hardness) that are important to ensure greatest efficacy should be considered.
- All pesticide spills should be addressed immediately using procedures identified in the refuge spill response plan.

5.2 Applying Pesticides

- Pesticide treatments should only be conducted by or under the supervision of Service personnel and non-Service applicators with the appropriate state certification to safely and effectively conduct these activities on refuge lands and waters.
- All Federal, state, and local pesticide use laws and regulations as well as Departmental, Service, and NWRS pesticide-related policies should be complied with. For example, as required under FIFRA, the proper application equipment and rates should be used for the specific pest(s) identified on the pesticide label.
- Before each treatment season and prior to mixing or applying any product for the first time each season, all applicators should review the labels, MSDSs, and Pesticide Use Proposal (PUPs) for each pesticide, determining the target pest, appropriate mix rate(s), PPE, and other requirements listed on the pesticide label.
- A no-spray buffer from the water's edge shall be as required by the U.S. Fish and Wildlife Service's May 2007 biological opinion.
- Low-impact herbicide application techniques (e.g., spot treatment, cut stump, oil basal, and Thinvert system applications) rather than broadcast foliar applications (e.g., boom sprayer and other larger tank wand applications) should be used, where practical.
- To maximize herbicide effectiveness and ensure correct and uniform application rates, low-volume rather than high-volume foliar applications should be used where the low-impact methods above are not feasible or practical.
- Applicators should use and adjust spray equipment to apply the coarsest droplet size spectrum with optimal coverage of the target species while reducing drift.
- Applicators should use the largest droplet size that results in uniform coverage.
- Applicators should use drift reduction technologies such as low-drift nozzles, where possible.
- Where possible, spraying should occur during low (average <7mph and preferably 3 to 5 mph) and consistent direction wind conditions with moderate temperatures (typically <85 ^{o}F).
- Where possible, applicators should avoid spraying during inversion conditions (often associated with calm and very low wind conditions) that can cause large-scale herbicide drift to non-target areas.
- Equipment should be calibrated regularly to ensure that the proper rate of pesticide is applied to the target area or species.
- Spray applications should be made at the lowest height for uniform coverage of target pests to minimize/eliminate potential drift.
- If windy conditions frequently occur during afternoons, spraying (especially boom

treatments) should typically be conducted during early morning hours.

- Spray applications should not be conducted on days with >30% forecast for rain within 6 hours, except for pesticides that are rapidly rain fast (e.g., glyphosate in 1 hour) to minimize/eliminate potential runoff.
- Where possible, applicators should use drift retardant adjuvants during spray applications, especially adjacent to sensitive areas.
- Where possible, applicators should use a non-toxic dye to aid in identifying target area treated as well as potential over spray or drift. A dye can also aid in detecting equipment leaks. If a leak is discovered, the application should be stopped until repairs can be made to the sprayer.
- For pesticide uses associated with cropland and facilities management, buffers, as appropriate, should be used to protect sensitive habitats, especially wetlands and other aquatic habitats.
- When drift cannot be sufficiently reduced through altering equipment set up and application techniques, buffer zones should be identified to protect sensitive areas downwind of applications. Applications adjacent to sensitive areas should only be made when the wind is blowing the opposite direction.
- Applicators should utilize scouting for early detection of pests to eliminate unnecessary pesticide applications.
- The timing of applications should be considered so native plants are protected (e.g., senescence) while effectively treating invasive plants.
- Rinsate from cleaning spray equipment should be recaptured and reused or applied to an appropriate pest plant infestation.
- Application equipment (e.g., sprayer, ATV, tractor) should be thoroughly cleaned and PPE removed/disposed of on-site by applicators after treatments to eliminate the potential spread of pests to un-infested areas.

6.0 Safety

6.1 Personal Protective Equipment

All applicators should wear the specific personal protective equipment (PPE) identified on the pesticide label. The appropriate PPE should be worn at all times during handling, mixing, and applying. PPE can include the following: disposable (e.g., Tyvek) or laundered coveralls; gloves (latex, rubber, or nitrile); rubber boots; and an NIOSH-approved respirator. Because exposure to concentrated product is usually greatest during mixing, extra care should be taken while preparing pesticide solutions. Persons mixing these solutions can be best protected if they wear long gloves, an apron, footwear, and a face shield.

Coveralls and other protective clothing used during an application should be laundered separately from other laundry items. Transporting, storing, handling, mixing, and disposing of pesticide containers should be consistent with label requirements, USEPA and OSHA requirements, and Service policy.

If a respirator is necessary for a pesticide use, then the following requirements must be met in accordance with Service safety policy (242 FW 12): a written Respirator Program, fit testing, physical examination (including pulmonary function and blood work for contaminants), and proper storage of the respirator.

6.2 Notification

The restricted entry interval (REI) is the time period required after the application at which point someone may safely enter a treated area without PPE. Refuge staff, Service authorized agents, volunteers, and members of the public who could be in or near a pesticide treated area within the stated re-entry time period on the label should be notified about treatment areas. Posting should occur at any site where individuals might inadvertently become exposed to a pesticide during other activities on a refuge. Where required by the label and/or state-specific regulations, sites should also be posted along their perimeter and at other likely locations of entry. The refuge staff should also notify appropriate private property owners (e.g., adjacent landowners) of an intended application, including any private individuals who have requested notification. Special efforts should be made to contact nearby individuals who are beekeepers or who have expressed chemical sensitivities.

6.3 Medical Surveillance

Medical surveillance may be required for Service personnel and approved volunteers who mix, apply, and/or monitor use of pesticides (see 242 FW 7, Pesticide Users and 242 FW 4, Medical Surveillance). Consistent with Service policy (242 FW 7.12A), Service personnel should be medically monitored if one or more of the following criteria is met: exposed or may be exposed to concentrations at or above the published permissible exposure limits or threshold limit values (see 242 FW 4); use pesticides in a manner considered "frequent pesticide use;" or use pesticides in a manner that requires a respirator (see 242 FW 14 for respirator use requirements). In Service policy (242 FW7.7A), "**Frequent Pesticide Use** means when a person applying pesticide handles, mixes, or applies pesticides, with a Health Hazard rating of 3 or higher, for 8 or more hours in any week or 16 or more hours in any 30-day period." Under some circumstances, individuals may be medically monitored who use pesticides infrequently (see section 7.7), experience an acute exposure (sudden, short term), or use pesticides with a health hazard ranking of 1 or 2. This monitoring decision should consider the individual's health and fitness level, the pesticide's specific health risks, and the potential risks from other pesticide-related activities. Refuge cooperators (e.g., cooperative farmers) and other authorized agents (e.g., state and county employees) are responsible for their own medical monitoring needs and costs.

Standard examinations (at Service expense) of appropriate refuge staff are provided by the nearest certified occupational health and safety physician as determined by Federal Occupational Health (a non-appropriated agency within the Program Support Center of the U.S. Department of Health and Human Services).

6.4 Certification and Supervision of Pesticide Applicators

Appropriate refuge staff or approved volunteers handling, mixing, and/or applying or directly supervising others engaged in pesticide use activities can be trained and be state or federally (USBLM) licensed to apply pesticides to refuge lands or waters. In accordance with 242

FW7.18A and 569 FW 1.10B, certification is required to apply restricted use pesticides based upon USEPA regulations. For safety reasons, all individuals participating in pest management activities with general use pesticides also are encouraged to attend appropriate training or acquire pesticide applicator certification. The certification requirement is for a commercial or private applicator depending upon the state. New staff unfamiliar with proper procedures for storing, mixing, handling, applying, and disposing of herbicides and containers should receive orientation and training before handling or using any products. Documentation of training should be kept in the files at the refuge office.

6.5 Record Keeping

6.5.1 Labels and material safety data sheets

Pesticide labels and material safety data sheets (MSDSs) should be maintained at the refuge shop and laminated copies should be kept in the mixing area. These documents also should be carried by field applicators, where possible. A written reference (e.g., note pad, chalk board, dry erase board) for each tank to be mixed should be kept in the mixing area for quick reference while mixing is in progress. Approved PUPs stored in the PUPS database typically contain website links (URLs) to pesticide labels and MSDSs.

6.5.2 Pesticide use proposals (PUPs)

A PUP is prepared for each proposed pesticide use associated with annual pest management on refuge lands and waters. A PUP includes specific information about the proposed pesticide use including the common and chemical names of the pesticide(s), target pest species, size and location of treatment site(s), application rate(s) and method(s), and federally listed species determinations, where applicable.

Upon meeting identified criteria, including an approved IPM plan, where necessary and consistent with Service guidelines (see Director's memo, December 12, 2007), refuge staff may receive up to a five-year approval for proposed pesticide uses that had been reviewed/approved by the field and Washington Office (see http://www.fws.gov/contaminants/Issues/IPM.cfm). For a refuge, an IPM plan (requirements described herein) can be completed independently or in association with a CCP or a habitat management plan (HMP) if IPM strategies and potential environmental effects are adequately addressed within appropriate NEPA documentation.

PUPs are created, approved, approved with modification, or disapproved, and stored as records in the Pesticide Use Proposal System (PUPS), which is a centralized database on the Service's intranet (https://systems.fws.gov/pups). Only Service employees can access PUP records in this database.

6.5.3 Pesticide usage

The refuge project leader is required to maintain annual records of all pesticides applied on lands or waters under refuge jurisdiction (569 FW 1). This would encompass pesticides applied by other Federal agencies, state and county governments, and non-governmental applicators, including cooperators and their U.S. Fish and Wildlife Service-approved pest management service providers. For clarification, pesticide means all insecticides, insect and plant growth regulators, desiccants, herbicides, fungicides, rodenticides, acaricides, nematicides, fumigants, avicides, and piscicides.

The following usage information can be reported for approved PUPs in the PUPS database.

- Pesticide trade name(s)
- Active ingredient(s)
- Total acres treated
- Total amount of pesticides used (lbs or gallons)
- Total amount of active ingredient(s) used (lbs)
- Target pest(s)
- Efficacy (% control)

To determine whether treatments are efficacious (eradicating, controlling, or containing the target pest) and achieving resource objectives, habitat and/or wildlife response should be monitored both pre- and post-treatment, where possible. Considering available annual funding and staffing, appropriate monitoring data regarding characteristics (attributes) of pest infestations (e.g., area, perimeter, degree of infestation-density, % cover, and density) as well as habitat and/or wildlife response to treatments may be collected and stored in a relational database (e.g., Refuge Habitat Management Database), preferably a geo-referenced data management system (e.g., Refuge Lands GIS) to facilitate data analyses and subsequent reporting. In accordance with adaptive management, data analysis and interpretation would allow treatments to be modified or changed over time, as necessary, to achieve resource objectives considering site-specific conditions in conjunction with habitat and/or wildlife responses. Monitoring can also identify short- and long-term impacts to natural resources and environmental quality associated with IPM treatments in accordance with adaptive management principles identified in Federal regulations (see 43 C.F.R. 46.145).

7.0 Evaluating Pesticide Use Proposals

Pesticides should only be used on refuge lands for habitat management as well as croplands or facilities maintenance after approval of a PUP. Potential effects to listed and non-listed species are evaluated with quantitative ecological risk assessments and other screening measures. Potential effects to environmental quality are based upon pesticide characteristics of environmental fate (water solubility, soil mobility, soil persistence, and volatilization) and other quantitative screening tools. Ecological risk assessments as well as characteristics of environmental fate and potential to degrade environmental quality for pesticides are documented in Chemical Profiles (see Section 7.5). These profiles include threshold values for quantitative measures of ecological risk assessments and screening tools for environmental fate that represent minimal potential effects to species and environmental quality. In general, only pesticide uses with appropriate BMPs (see Section 4.0) for habitat management and cropland or facilities maintenance on refuge lands that would potentially have minor, temporary, or localized effects on refuge biological resources and environmental quality (threshold values not exceeded) are approved.

7.1 Overview of Ecological Risk Assessment

An ecological risk assessment process is used to evaluate potential adverse effects to biological resources as a result of a pesticide(s) proposed for use on refuge lands. This process is an established quantitative and qualitative method for comparing and prioritizing risks of pesticides and conveying an estimate of the potential risk for an adverse effect. This quantitative methodology provides an efficient mechanism to integrate best available scientific information regarding hazard, patterns of use (exposure), and dose-response relationships in a manner that is useful for ecological risk decision-making. It provides an effective means to evaluate potential effects where there is missing or unavailable scientific information (data gaps) to address reasonable, foreseeable adverse effects in the field as required under Federal regulations (40 C.F.R. Part 1502.22). Protocols for ecological risk assessment of pesticide uses on the refuge were developed through research and established by the US Environmental Protection Agency (2004). Assumptions for these risk assessments are presented in Section 7.2.3.

The toxicological data used in ecological risk assessments are typically results of standardized laboratory studies provided by pesticide registrants to the USEPA to meet regulatory requirements under FIFRA. These studies assess the acute (lethality) and chronic (reproductive) effects associated with short- and long-term exposure to pesticides on representative species of birds, mammals, freshwater fish, aquatic invertebrates, and terrestrial and aquatic plants. Other effects data that are publicly available are also utilized for risk assessment protocols described herein. Toxicity endpoint and environmental fate data are available from a variety of resources. Some of the more useful resources can be found in Section 7.5.

Table 1. Ecotoxicity tests used to evaluate potential effects to birds, fish, and mammals to establish toxicity endpoints for risk quotient calculations.

Species Group	**Exposure**	**Measurement endpoint**
Bird	Acute	Median Lethal Concentration (LC_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[1]
Fish	Acute	Median Lethal Concentration (LC_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[2]
Mammal	Acute	Oral Lethal Dose (LD_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[3]

[1]Measurement endpoints typically include a variety of reproductive parameters (e.g., number of eggs, number of offspring, eggshell thickness, and number of cracked eggs).
[2]Measurement endpoints for early life stage/life cycle typically include embryo hatch rates, time to hatch, growth, and time to swim-up.
[3]Measurement endpoints include maternal toxicity, teratogenic effects or developmental anomalies, evidence of mutagenicity or genotoxicity, and interference with cellular mechanisms such as DNA synthesis and DNA repair.

7.2 Determining Ecological Risk to Fish and Wildlife

The potential for pesticides used on a refuge to cause direct adverse effects to fish and wildlife are evaluated using USEPA's Ecological Risk Assessment Process (USEPA, 2004). This deterministic approach, which is based upon a two-phase process involving estimation of environmental concentrations and then characterization of risk, would be used for ecological risk assessments. This method integrates exposure estimates (estimated environmental concentration [EEC] and toxicological endpoints [e.g., LC_{50} and oral LD_{50}]) to evaluate the potential for adverse effects to species groups (birds, mammals, and fish) representative of legal mandates for managing units of the NWRS. This integration is achieved through risk quotients (RQs) calculated by dividing the EEC by acute and chronic toxicity values selected from standardized toxicological endpoints or published effect (Table 1).

$$RQ = EEC/Toxicological\ Endpoint$$

The level of risk associated with direct effects of pesticide use are characterized by comparing calculated RQs to the appropriate Level of Concern (LOC) established by US Environmental Protection Agency (USEPA, 1998 [Table 2]). The LOC represents a quantitative threshold value for screening potential adverse effects to fish and wildlife resources associated with pesticide use. Following are four exposure-species group scenarios that would are used to characterize ecological risk to fish and wildlife on a refuge: acute-listed species, acute-non-listed species, chronic-listed species, and chronic-non-listed species.

Acute risk indicates the potential for mortality associated with short-term dietary exposure to pesticides immediately after an application. For characterization of acute risks, median values from LC_{50} and LD_{50} tests are used as toxicological endpoints for RQ calculations. In contrast, chronic risks indicate the potential for adverse effects associated with long-term dietary exposure to pesticides from a single application or multiple applications over time (within a season and over years). For characterization of chronic risks, no observed adverse effect concentrations (NOAEC) or no observed effect concentrations (NOEC) for reproduction are used as toxicological endpoints for RQ calculations. Where available, the NOAEC is preferred over a NOEC value.

Listed species are those federally designated as threatened, endangered, or proposed in accordance with the Endangered Species Act of 1973 (16 U.S.C. 1531-1544). For listed species, potential adverse effects are assessed at the individual level because loss of individuals from a population can detrimentally impact a species. In contrast, risks to non-listed species are considered at the population level. A RQ<LOC indicates the proposed pesticide use "may affect, not likely to adversely affect" individuals (listed species) and it would not pose an unacceptable risk for adverse effects to populations (non-listed species) for each taxonomic group (Table 2). In contrast, an RQ>LOC would indicate a "may affect, likely to adversely affect" for listed species and it would also pose unacceptable ecological risk for adverse effects to non-listed species.

Table 2. Presumption of unacceptable risk for birds, fish, and mammals (USEPA, 1998).

Risk Presumption		Level of Concern	
		Listed Species	Non-listed Species
Acute	Birds	0.1	0.5
	Fish	0.05	0.5
	Mammals	0.1	0.5
Chronic	Birds	1.0	1.0
	Fish	1.0	1.0
	Mammals	1.0	1.0

7.2.1 Environmental exposure

Following release into the environment through application, pesticides experience several different routes of environmental fate. Pesticides which are sprayed can move through the air (e.g., particle or vapor drift) and may eventually end up in other parts of the environment such as non-target vegetation, soil, or water. Pesticides applied directly to the soil may be washed off the soil into nearby bodies of surface water (e.g., surface runoff) or may percolate through the soil to lower soil layers and groundwater (e.g., leaching) (Baker and Miller 1999, Pope et. al. 1999, Butler et. al. 1998, Ramsay et. al. 1995, EXTOXNET 1993*a*). Pesticides which are injected into the soil may also be subject to the latter two fates. The aforementioned possibilities are by no means comprehensive, but they illustrate that movement of pesticides in the environment is very complex with transfers occurring continually among different environmental compartments. In some cases, these exchanges occur not only between areas that are close together, but also may involve transportation of pesticides over long distances (Barry 2004, Woods 2004).

7.2.1.1 Terrestrial exposure

The ECC for exposure to terrestrial wildlife is quantified using an USEPA screening-level approach (USEPA. 2004). This screening-level approach is not affected by product formulation because it evaluates pesticide active ingredient(s). This approach varies depending upon the proposed pesticide application method (e.g., spray or granular).

7.2.1.1.1 Terrestrial-spray application

For spray applications, exposure is determined using the Kanaga nomogram method (USEPA, 2005*a*, USEPA. 2004, Pfleeger et al*.* 1996) through the USEPA's Terrestrial Residue Exposure model (T-REX) version 1.2.3 (USEPA. 2005*b*). To estimate the maximum (initial) pesticide residue on short grass (<20 cm tall) as a general food item category for terrestrial vertebrate species, T-REX input variables include the following from the pesticide label: maximum pesticide application rate (pounds active ingredient [acid equivalent]/acre) and pesticide half-life (days) in soil. Although there are other food item categories (tall grasses; broadleaf plants and small insects; and fruits, pods, seeds and large insects), short grass was selected because it yields maximum EECs (240 ppm per lb ai/acre) for worst-case risk assessments. Short grass is not representative of forage for carnivorous species (e.g., raptors), but it characterizes the maximum potential exposure through the diet of avian and mammalian prey items. Consequently, this approach provides a conservative screening tool for pesticides that do not biomagnify.

For RQ calculations in T-REX, the model requires the weight of surrogate species and Mineau scaling factors (Mineau et. al. 1996). Body weights of bobwhite quail and mallard are included in T-REX by default, but body weights of other organisms (Table 3) can be entered manually. The Mineau scaling factor accounts for small-bodied bird species that may be more sensitive to pesticide exposure than would be predicted only by body weight. Mineau scaling factors are entered manually with values ranging from 1 to 1.55 that are unique to a particular pesticide or group of pesticides. If specific information to select a scaling factor is not available, then a value of 1.15 is used as a default. Alternatively, zero is entered if it is known that body weight does not influence toxicity of pesticide(s) being assessed. The upper bound estimate output from the T-REX Kanaga nomogram is used as an EEC for calculation of RQs. This approach yields a conservative estimate of ecological risk.

Table 3. Average body weight of selected terrestrial wildlife species frequently used in research to establish toxicological endpoints (Dunning 1984).

Species	**Body Weight (kg)**
Mammal (15 g)	0.015
House sparrow	0.0277
Mammal (35 g)	0.035
Starling	0.0823
Red-winged blackbird	0.0526
Common grackle	0.114
Japanese quail	0.178
Bobwhite quail	0.178
Rat	0.200
Rock dove (aka pigeon)	0.542
Mammal (1000 g)	1.000
Mallard	1.082
Ring-necked pheasant	1.135

7.2.1.1.2 Terrestrial – granular application

Granular pesticide formulations and pesticide-treated seed pose a unique route of exposure for avian and mammalian species. The pesticide is applied in discrete units which birds or mammals might ingest accidentally with food items or intentionally as in the case of some bird species actively seeking and picking up gravel or grit to aid digestion or seed as a food source. Granules may also be consumed by wildlife foraging on earthworms, slugs or other soft-bodied soil organisms to which the granules may adhere.

Terrestrial wildlife RQs for granular formulations or seed treatments are calculated by dividing the maximum milligrams of active ingredient (ai) exposed (e.g., EEC) on the surface of an area equal to 1 square foot by the appropriate LD_{50} value multiplied by the surrogate's body weight (Table 3). An adjustment to surface area calculations is made for broadcast, banded, and in-furrow applications. An adjustment is also made for applications with and without incorporation of the granules. Without incorporation, it is assumed that 100% of the granules remain on the soil surface available to foraging birds and mammals. Press wheels push granules flat with the soil surface, but they are not incorporated into the soil. If granules are incorporated in the soil during band or T-band applications or after broadcast applications, it is assumed only 15% of the applied granules remain available to wildlife. It is assumed that only 1% of the granules are available on the soil surface following in-furrow applications.

EECs for pesticides applied in granular form and as seed treatments are determined considering potential ingestion rates of avian or mammalian species (e.g., 10-30% body weight/day). This provides an estimate of maximum exposure that may occur as a result of granule or seed treatment spills such as those that commonly occur at end rows during application and planting. The availability of granules and seed treatments to terrestrial vertebrates is also considered by calculating the loading per unit area (LD_{50}/ft^2) for comparison to USEPA Level of Concerns (US Environmental Protection Agency 1998). The T-REX version 1.2.3 (USEPA, 2005*b*) contains a submodel which automates Kanaga exposure calculations for granular pesticides and treated seed.

The following formulas are used to calculate EECs depending upon the type of granular pesticide application.

- In-furrow applications assume a typical value of 1% granules, bait, or seed remain unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/acre)(\%\ a.i.)(453{,}580\ mg/lbs)(1\%\ exposed))] / \{[(43{,}560\ ft.^2/acre)/(row\ spacing\ (ft.))] / (row\ spacing\ (ft.)\}$$

or

$$mg\ a.i./ft^2 = [(lbs\ product/1000\ ft.\ row)(\%\ a.i.)(1000\ ft\ row)(453{,}580\ mg/lb.)(1\%\ exposed)$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

- Incorporated banded treatments assume that 15% of granules, bait, and seeds are unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/1000\ row\ ft.)(\%\ a.i.)(453{,}580\ mg/lb.)(1\text{-}\%\ incorporated)] / (1{,}000\ ft.)(band\ width\ (ft.))$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

- Broadcast treatment without incorporation assumes 100% of granules, bait, seeds are unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/acre)(\%\ a.i.)(453{,}590\ mg/lb.)] / (43{,}560\ ft.^2/acre)$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

Where:

- *% of pesticide biologically available = 100% without species specific ingestion rates*

- *Conversion for calculating mg a.i./ft.^{2} using ounces: 453,580 mg/lb. /16 = 28,349 mg/oz.*

The following equation is used to calculate an RQ based on the EEC calculated by one of the above equations. The EEC is divided by the surrogate LD_{50} toxicological endpoint multiplied by the body weight (Table 3) of the surrogate.

$$RQ = EEC / [LD_{50} (mg/kg) * body\ weight\ (kg)]$$

As with other risk assessments, an RQ>LOC would be a presumption of unacceptable ecological risk. An RQ<LOC would be a presumption of acceptable risk with only minor, temporary, or localized effects to species.

7.2.1.2 Aquatic exposure

Exposures to aquatic habitats (e.g., wetlands, meadows, ephemeral pools, water delivery ditches) are evaluated separately for ground-based pesticide treatments of habitats managed for fish and wildlife compared with cropland and facilities maintenance. The primary exposure pathway for aquatic organisms from any ground-based treatments is likely particle drift during the pesticide application. However, different exposure scenarios are necessary as a result of contrasting application equipment and techniques as well as pesticides used to control pests on agricultural lands (especially those cultivated by cooperative farmers for economic return from crop yields) and facilities maintenance (e.g., roadsides, parking lots, trails) compared with other managed habitats on a refuge. In addition, pesticide applications may be made <25 feet from the high water mark of aquatic habitats for habitat management treatments; whereas, no-spray buffers (≥25 feet) are used for croplands/facilities maintenance treatments.

7.2.1.2.1 Habitat treatments

For the worst-case exposure scenario to non-target aquatic habitats, EECs (Table 4) are derived from Urban and Cook (1986). They assume an intentional overspray to an entire, non-target water body (1-foot depth) from a treatment <25 feet from the high water mark using the max application rate (acid basis [see above]). However, use of BMPs for applying pesticides (see Section 4.2) likely minimize/eliminate potential drift to non-target aquatic habitats during actual treatments. If there is unacceptable (acute or chronic) risk to fish and wildlife with the simulated 100% overspray (RQ>LOC), then the proposed pesticide use may be disapproved or the PUP may be approved at a lower application rate to minimize/eliminate unacceptable risk to aquatic organisms (RQ=LOC).

Table 4. Estimated Environmental Concentrations (ppb) of pesticides in aquatic habitats (1 foot depth) immediately after direct application (Urban and Cook 1986).

Lbs/acre	EEC (ppb)
0.10	36.7
0.20	73.5
0.25	91.9
0.30	110.2
0.40	147.0
0.50	183.7
0.75	275.6
1.00	367.5
1.25	459.7
1.50	551.6
1.75	643.5
2.00	735.7
2.25	827.6
2.50	919.4
3.00	1103.5
4.00	1471.4
5.00	1839
6.00	2207
7.00	2575
8.00	2943
9.00	3311
10.00	3678

7.2.1.2.2 Cropland/facilities maintenance treatments

Field drift studies conducted by the Spray Drift Task Force, which is a joint project of several agricultural chemical businesses, were used to develop a generic spray drift database (U.S. EPA, https://www.epa.gov/pesticide-registration/prn-90-3-announcing-formation-industry-wide-spray-drift-task-force-notice). The AgDRIFT computer model was created from this database to satisfy USEPA pesticide registration spray drift data requirements and as a scientific basis to evaluate off-target movement of pesticides from particle drift and assess potential effects of exposure to wildlife. Several versions of the computer model have been developed (i.e., v2.01 through v2.10). The Spray Drift Task Force AgDRIFT® model version 2.01 (SDTF 2003, AgDRIFT 2001) is used to derive EECs resulting from drift of pesticides to refuge aquatic resources from ground-based pesticide applications >25 feet from the high water mark. The Spray Drift Task Force AgDRIFT model is publicly available at http://www.agdrift.com. At this website, click “AgDRIFT 2.0” and then click “Download Now” and follow the instructions to obtain the computer model.

The AgDRIFT model is composed of submodels called tiers. Tier I Ground submodel is used to assess ground-based applications of pesticides. Tier outputs (EECs) are calculated with AgDRIFT using the following input variables: max application rate (acid basis [see above]), low boom (20 inches), fine to medium droplet size, EPA-defined wetland, and a ≥25-foot distance (buffer) from treated area to water.

7.2.2 Use of information on effects of biological control agents, pesticides, degradates, and adjuvants

Consistent with Federal regulations (see 43 CFR 46.135), the Service specifically incorporates through reference ecological risk assessments prepared by the U.S. Forest Service (http://www.fs.fed.us/r6/invasiveplant-eis/Risk-Assessments/Herbicides-Analyzed-InvPlant-EIS.htm) and U.S. Bureau of Land Management (http://www.blm.gov/wo/st/en/prog/more/veg_eis.html). These risk assessments and associated documentation also are available in total with the administrative record for the Final Environmental Impact Statement entitled *Pacific Northwest Region Invasive Plant Program – Preventing and Managing Invasive Plants* (USFS, 2005) and *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic EIS (PEIS)* (USBLM, 2007). Federal regulations also state that use of existing NEPA documents by supplementing, tiering to, incorporating through reference, or adopting previous NEPA environmental analyses avoids redundancy and unnecessary paperwork (see 43 CRF 46.120(d)).

For example, ecological risk assessments for the following herbicide and adjuvant uses prepared by the U.S. Forest Service could be incorporated through reference and provide a basis for completing "Chemical Profiles" to be used for approving or disapproving refuge PUPs.

- 2,4-D
- Chlorosulfuron
- Clopyralid
- Dicamba
- Glyphosate
- Imazapic
- Imazapyr
- Metsulfuron methyl
- Picloram
- Sethoxydim
- Sulfometuron methyl
- Triclopyr
- Nonylphenol polyethylate (NPE) based surfactants [Perhaps it should read "Nonylphenol ethoxylate (NPE) based surfactants" or "Nonylphenol polyethoxylate (NPE) based surfactants"]

Also, ecological risk assessments for the following herbicide uses and evaluations of risks associated with pesticide degradates and adjuvants prepared by the U.S. Bureau of Land Management could be incorporated through reference and provide a basis for completing "Chemical Profiles" to be used for approving or disapproving refuge PUPs.

- Bromacil
- Chlorsulfuron
- Diflufenzopyr
- Diquat
- Diuron
- Fluridone
- Imazapic
- Overdrive (diflufenzopyr and dicamba)
- Sulfometuron methyl
- Tebuthiuron
- Pesticide degradates and adjuvants (*Appendix D – Evaluation of risks from degradates, polyoxyethylene-amine (POEA) and R-11, and endocrine disrupting chemicals*)

7.2.3 Assumptions for ecological risk assessments

There are a number of assumptions involved with the ecological risk assessment process for terrestrial and aquatic organisms associated with utilization of the US Environmental Protection Agency's (2004) process. These assumptions may be risk neutral or may lead to an over- or under-estimation of risk from pesticide exposure depending upon site-specific conditions. The following describes these assumptions, their application to the conditions typically encountered, and whether or not they may lead to recommendations that are risk neutral, underestimate, or overestimate ecological risk from potential pesticide exposure.

- Indirect effects are not be evaluated by ecological risk assessments. These effects include the mechanisms of indirect exposure to pesticides: consuming prey items (fish, birds, or small mammals), reductions in the availability of prey items, and disturbance associated with pesticide application activities.
- Exposure to a pesticide product is assessed based upon the active ingredient. However, exposure to a chemical mixture (pesticide formulation) may result in effects that are similar or substantially different compared to only the active ingredient. Non-target organisms may be exposed directly to the pesticide formulation or only various constituents of the formulation as they dissipate and partition in the environment. If toxicological information for both the active ingredient and formulated product are available, then data representing the greatest potential toxicity is selected for use in the risk assessment process (USEPA, 2004). As a result, this conservative approach may lead to an overestimation of risk characterization from pesticide exposure.
- Because toxicity tests with listed or candidate species or closely related species are not available, data for surrogate species is most often used for risk assessments. Specifically, bobwhite quail and mallard duck are the most frequently used surrogates for evaluating potential toxicity to federally listed avian species. Bluegill sunfish, rainbow trout, and fathead minnow are the most common surrogates for evaluating toxicity for freshwater fishes; and sheep's head minnow can be an appropriate surrogate marine species for coastal environments. Rats and mice are the most common surrogates for evaluating toxicity for mammals. Interspecies sensitivity is a major source of uncertainty in pesticide assessments. As a result of this uncertainty, data is selected for the most sensitive species tested within a taxonomic group (birds, fish, and mammals) given the quality of the data is acceptable. If

additional toxicity data for more species or organisms in a particular group are available, the selected data are not limited to the species previously listed as common surrogates.

- The Kanaga nomogram outputs maximum EEC values that may be used to calculate an average daily concentration over a specified interval of time, which is referred to as a time-weighted-average (TWA). The maximum EEC would be selected as the exposure input for both acute and chronic risk assessments in the screening-level evaluations. The initial or maximum EEC derived from the Kanaga nomogram represents the maximum expected instantaneous or acute exposure to a pesticide. Acute toxicity endpoints are determined using a single exposure to a known pesticide concentration, typically for 48 to 96 hours. This value is assumed to represent ecological risk from acute exposure to a pesticide. On the other hand, chronic risk to pesticide exposure is a function of pesticide concentration and duration of exposure to the pesticide. An organism's response to chronic pesticide exposure may result from either the concentration of the pesticide, length of exposure, or some combination of both factors. Standardized tests for chronic toxicity typically involve exposing an organism to several different pesticide concentrations for a specified length of time (days, weeks, months, years or generations). For example, avian reproduction tests include a 10-week exposure phase. Because a single length of time is used in the test, time response data are usually not available for inclusion into risk assessments. Without time response data it is difficult to determine the concentration which elicited a toxicological response.
- Using maximum EECs for chronic risk estimates may result in an overestimate of risk, particularly for compounds that dissipate rapidly. Conversely, using TWAs for chronic risk estimates may underestimate risk if it is the concentration rather than the duration of exposure that is primarily responsible for the observed adverse effect. The maximum EEC is used for chronic risk assessments although it may result in an overestimate of risk. TWAs may be used for chronic risk assessments, but they will be applied judiciously considering the potential for an underestimate or overestimate of risk. For example, the number of days exposure exceeds a Level of Concern may influence the suitability of a pesticide use. The greater the number of days the EEC exceeds the Level of Concern translates into greater the ecological risk. This is a qualitative assessment, and is subject to reviewer's expertise in ecological risk assessment and tolerance for risk.
- The length of time used to calculate the TWA can have a substantial effect on the exposure estimates and there is no standard method for determining the appropriate duration for this estimate. The T-REX model assumes a 21-week exposure period, which is equivalent to avian reproductive studies designed to establish a steady-state concentration for bioaccumulative compounds. However, this does not necessarily define the true exposure duration needed to elicit a toxicological response. Pesticides, which do not bioaccumulate, may achieve a steady-state concentration earlier than 21 weeks. The duration of time for calculating TWAs will require justification and it will not exceed the duration of exposure in the chronic toxicity test (approximately 70 days for the standard avian reproduction study). An alternative to using the duration of the chronic toxicity study is to base the TWA on the application interval. In this case, increasing the application interval would suppress both the estimated peak pesticide concentration and the TWA. Another alternative to using TWAs would be to consider the number of days that a chemical is predicted to exceed the LOC.
- Pesticide dissipation is assumed to be first-order in the absence of data suggesting alternative dissipation patterns such as bi-phasic. Field dissipation data would generally be the most pertinent for assessing exposure in terrestrial species that forage on vegetation. However,

these data are often not available and they can be misleading particularly if the compound is prone to “wash-off.” Soil half-life are the most common degradation data available. Dissipation or degradation data that would reflect the environmental conditions typical of refuge lands are utilized, if available.

- For species found in the water column, it is assumed that the greatest bioavailable fraction of the pesticide active ingredient in surface waters is freely dissolved in the water column.
- Actual habitat requirements of any particular terrestrial species are not considered, and it is assumed that species exclusively and permanently occupy the treated area, or adjacent areas receiving pesticide at rates commensurate with the treatment rate. This assumption produces a maximum estimate of exposure for risk characterization. This assumption likely overestimates exposure for species that do not permanently and exclusively occupy the treated area (USEPA, 2004).
- Exposure through incidental ingestion of pesticide contaminated soil is not considered in the USEPA risk assessment protocols. Research suggests <15% of the diet can consist of incidentally ingested soil depending upon species and feeding strategy (Beyer et al. 1994). An assessment of pesticide concentrations in soil compared to food item categories in the Kanaga nomogram indicates incidental soil ingestion likely does not increase dietary exposure to pesticides. Inclusion of soil into the diet would effectively reduce the overall dietary concentration compared to the present assumption that the entire diet consists of a contaminated food source (Fletcher et al. 1994). An exception to this may be soil-applied pesticides in which exposure from incidental ingestion of soil may increase. The potential for pesticide exposure under this assumption may be underestimated for soil-applied pesticides and overestimated for foliar-applied pesticides. The concentration of a pesticide in soil would likely be less than predicted on food items.
- Exposure through inhalation of pesticides is not considered in the USEPA risk assessment protocols. Such exposure can occur through three potential sources: spray material in droplet form at time of application, vapor phase with the pesticide volatilizing from treated surfaces, and airborne particulates (soil, vegetative matter, and pesticide dusts). The USEPA (1990) reported exposure from inhaling spray droplets at the time of application is not an appreciable route of exposure for birds. According to research on mallards and bobwhite quail, respirable particle size (particles reaching the lung) in birds is limited to maximum diameter of 2 to 5 microns. The spray droplet spectra covering the majority of pesticide application scenarios indicate that less than 1% of the applied material is within the respirable particle size. This route of exposure is further limited because the permissible spray drop size distribution for ground pesticide applications is restricted to ASAE medium or coarser drop size distribution.
- Inhalation of a pesticide in the vapor phase can be another source of exposure for some pesticides under certain conditions. This mechanism of exposure to pesticides occurs post application, and it pertains to those pesticides with a high vapor pressure. The USEPA is currently evaluating protocols for modeling inhalation exposure from pesticides including near-field and near-ground air concentrations based upon equilibrium and kinetics-based models. Risk characterization for exposure with this mechanism is unavailable.
- The effect from exposure to dusts contaminated with the pesticide cannot be assessed generically as partitioning issues related to application site soils and chemical properties of the applied pesticides render the exposure potential from this route highly situation specific.

- Dermal exposure can occur through three potential sources: direct application of spray to terrestrial wildlife in the treated area or within the drift footprint, incidental contact with contaminated vegetation, or contact with contaminated water or soil. Interception of spray and incidental contact with treated substrates may pose risk to avian wildlife (Driver et al. 1991). However, available research related to wildlife dermal contact with pesticides is extremely limited, except dermal toxicity values are common for some mammals used as human surrogates (rats and mice). The USEPA is currently evaluating protocols for modeling dermal exposure. Risk characterization may be underestimated for this route of exposure, particularly with high risk pesticides such as some organophosphates or carbamate insecticides. If protocols are established by the USEPA for assessing dermal exposure to pesticides, they will be considered for incorporation into pesticide assessment protocols.
- Exposure to a pesticide can occur from consuming surface water, dew, or other water on treated surfaces. Water-soluble pesticides have the potential to dissolve in surface runoff and puddles in a treated area can contain pesticide residues. Similarly, pesticides with lower organic carbon partitioning characteristics and higher solubility in water have a greater potential to dissolve in dew and other water associated with plant surfaces. Estimating the extent to which such pesticide loadings to drinking water occurs is complex and would depend upon the partitioning characteristics of the active ingredient, soils types in the treatment area, and the meteorology of the treatment area. In addition, the use of various water sources by wildlife is highly species-specific. Currently, risk characterization for this exposure mechanism is not available. The USEPA is actively developing protocols to quantify drinking water exposures from puddles and dew. If and when protocols are formally established by the USEPA for assessing exposure to pesticides through drinking water, these protocols will be incorporated into pesticide risk assessment protocols.
- Risk assessments are based upon the assumption that the entire treatment area is subject to pesticide application at the rates specified on the label. In most cases, there is potential for uneven application of pesticides through such plausible incidents as changes in calibration of application equipment, spillage, and localized releases at specific sites in or near the treated field that are associated with mixing and handling and application equipment as well as applicator skill. Inappropriate use of pesticides and the occurrence of spills represent a potential underestimate of risk. It is likely not an important factor for risk characterization. All pesticide applicators are required to be certified by the state in which they apply pesticides. Certification training includes the safe storage, transport, handling, and mixing of pesticides; equipment calibration; and proper application with annual continuing education.
- The USEPA relies on Fletcher (1994) for setting the assumed pesticide residues in wildlife dietary items. The USEPA (2004) "believes that these residue assumptions reflect a realistic upper-bound residue estimate, although the degree to which this assumption reflects a specific percentile estimate is difficult to quantify." Fletcher's (1994) research suggests that the pesticide active ingredient residue assumptions used by the USEPA represent a 95th percentile estimate. However, research conducted by Pfleeger et al. (1996) indicates USEPA residue assumptions for short grass were not exceeded. Baehr and Habig (2000) compared USEPA residue assumptions with distributions of measured pesticide residues for the USEPA's UTAB database. Overall residue selection level will tend to overestimate risk characterization. This is particularly evident when wildlife individuals are likely to have selected a variety of food items acquired from multiple locations. Some food items may be contaminated with pesticide residues whereas others are not contaminated. However, it is

important to recognize differences in species feeding behavior. Some species may consume whole above-ground plant material, but others will preferentially select different plant structures. Also, species may preferentially select a single food item although multiple food items are present. Without species-specific knowledge regarding foraging behavior, characterizing ecological risk other than in general terms is not possible.

- Acute and chronic risk assessments rely on comparisons of wildlife dietary residues with LC_{50} or NOEC values expressed as concentrations of pesticides in laboratory feed. These comparisons assume that ingestion of food items in the field occurs at rates commensurate with those in the laboratory. Although the screening assessment process adjusts dry-weight estimates of food intake to reflect the increased mass in fresh-weight wildlife food intake estimates, it does not allow for gross energy and assimilative efficiency differences between wildlife food items and laboratory feed. Differences in assimilative efficiency between laboratory and wild diets suggest that current screening assessment methods are not accounting for a potentially important aspect of food requirements.
- There are several other assumptions that can affect non-target species not considered in the risk assessment process. These include possible additive or synergistic effects from applying two or more pesticides or additives in a single application, co-location of pesticides in the environment, cumulative effects from pesticides with the same mode of action, effects of multiple stressors (e.g., combination of pesticide exposure, adverse abiotic and biotic factors) and behavioral changes induced by exposure to a pesticide. These factors may exist at some level contributing to adverse effects to non-target species, but they are usually characterized in the published literature in only a general manner limiting their value in the risk assessment process.
- It is assumed that aquatic species exclusively and permanently occupy the water body being assessed. Actual habitat requirements of aquatic species are not considered. With the possible exception of scenarios where pesticides are directly applied to water, it is assumed that no habitat use considerations specific for any species would place the organisms in closer proximity to pesticide use sites. This assumption produces a maximum estimate of exposure or risk characterization. It would likely be realistic for many aquatic species that may be found in aquatic habitats within or in close proximity to treated terrestrial habitats. However, the spatial distribution of wildlife is usually not random because wildlife distributions are often related to habitat requirements of species. Clumped distributions of wildlife may result in an under- or over-estimation of risk depending upon where the initial pesticide concentration occurs relative to the species or species habitat.
- For species found in the water column, it is assumed that the greatest bioavailable fraction of the pesticide active ingredient in surface waters is freely dissolved in the water column. Additional chemical exposure from materials associated with suspended solids or food items is not considered because partitioning onto sediments likely is minimal. Adsorption and bioconcentration occurs at lower levels for many newer pesticides compared with older more persistent bioaccumulative compounds. Pesticides with RQs close to the listed species level of concern, the potential for additional exposure from these routes may be a limitation of risk assessments, where potential pesticide exposure or risk may be underestimated.
- Mass transport losses of pesticide from a water body (except for losses by volatilization, degradation and sediment partitioning) are not considered for ecological risk assessment. The water body is assumed to capture all pesticide active ingredients entering as runoff, drift, and adsorbed to eroded soil particles. It’s also assumed that a pesticide’s active ingredient is not

lost from the water body by overtopping or flow-through, nor is concentration reduced by dilution. In total, these assumptions lead to a near maximum possible water-borne concentration. However, this assumption does not account for the potential to concentrate pesticide through the evaporative loss. This limitation may have the greatest impact on water bodies with high surface-to-volume ratios such as ephemeral wetlands, where evaporative losses are accentuated and applied pesticides have low rates of degradation and volatilization.

- For acute risk assessments, there is no averaging time for exposure. An instantaneous peak concentration is assumed, where instantaneous exposure is sufficient in duration to elicit acute effects comparable to those observed over more protracted exposure periods (typically 48 to 96 hours) tested in the laboratory. In the absence of data regarding time-to-toxic event, analyses and latent responses to instantaneous exposure, risk is likely overestimated.
- For chronic exposure risk assessments, the averaging times considered for exposure are commensurate with the duration of invertebrate life-cycle or fish-early life stage tests (e.g., 21-28 days and 56-60 days, respectively). Response profiles (time-to-effect and latency-of-effect) to pesticides likely vary widely with mode of action and species and should be evaluated on a case-by-case basis as available data allow. Nevertheless, because the USEPA relies on chronic exposure toxicity endpoints based on a finding of no observed effect, the potential for any latent toxicity effects or averaging time assumptions to alter the results of an acceptable chronic risk assessment prediction is limited. The extent to which duration of exposure from water-borne concentrations overestimate or underestimate actual exposure depends on several factors. These include the following: localized meteorological conditions, runoff characteristics of the watershed (e.g., soils and topography), the hydrological characteristics of receiving waters, environmental fate of the pesticide active ingredient, and the method of pesticide application. It should also be understood that chronic effects studies are performed using a method that holds water concentration in a steady state. This method is not likely to reflect conditions associated with pesticide runoff. Pesticide concentrations in the field increase and decrease in surface water on a cycle influenced by rainfall, pesticide use patterns, and degradation rates. As a result of the dependency of this assumption on several undefined variables, risk associated with chronic exposure may in some situations underestimate risk and overestimate risk in others.
- There are several other factors that can affect non-target species not considered in the risk assessment process. These include the following: possible additive or synergistic effects from applying two or more pesticides or additives in a single application, co-location of pesticides in the environment, cumulative effects from pesticides with the same mode of action, effects of multiple stressors (e.g., combination of pesticide exposure, adverse abiotic [not pesticides] and biotic factors), and sub-lethal effects such as behavioral changes induced by exposure to a pesticide. These factors may exist at some level contributing to adverse effects to non-target species, but they are not routinely assessed by regulatory agencies. Therefore, information on the factors is not extensive limiting their value for the risk assessment process. As this type of information becomes available, it is included, either quantitatively or qualitatively, in this risk assessment process.
- USEPA is required by the Food Quality Protection Act to assess the cumulative risks of pesticides that share common mechanisms of toxicity, or act the same within an organism. Currently, USEPA has identified four groups of pesticides that have a common mechanism of toxicity requiring cumulative risk assessments. These four groups are: the

organophosphate insecticides, N-methyl carbamate insecticides, triazine herbicides, and chloroacetanilide herbicides.

7.3 Pesticide Mixtures and Degradates

Pesticide products are usually a formulation of several components generally categorized as active ingredients and inert or other ingredients. The term active ingredient is defined by the FIFRA as preventing, destroying, repelling, or mitigating the effects of a pest, or it is a plant regulator, defoliant, desiccant, or nitrogen stabilizer. In accordance with FIFRA, the active ingredient(s) must be identified by name(s) on the pesticide label along with its relative composition expressed in percentage(s) by weight. In contrast, inert ingredient(s) are not intended to affect a target pest. Their role in the pesticide formulation is to act as a solvent (keep the active ingredient is a liquid phase), an emulsifying or suspending agent (keep the active ingredient from separating out of solution), or a carrier (such as clay in which the active ingredient is impregnated on the clay particle in dry formulations). For example, if isopropyl alcohol would be used as a solvent in a pesticide formulation, then it would be considered an inert ingredient. FIFRA only requires that a product label declare the total percentage of all inert ingredients and inert ingredients identified as hazardous and associated percent composition. Inert ingredients that are not classified as hazardous are not required to be identified.

The USEPA (September 1997) issued Pesticide Regulation Notice 97-6, which encouraged manufacturers, formulators, producers, and registrants of pesticide products to voluntarily substitute the term "other ingredients" for "inert ingredients" in the ingredient statement. This change recognized that all components in a pesticide formulation could potentially elicit or contribute to an adverse effect on non-target organisms and, therefore, are not necessarily inert. Whether referred to as "inerts" or "other ingredients," these constituents within a pesticide product have the potential to affect species or environmental quality. The USEPA categorizes regulated inert ingredients into the following four lists (http://www.epa.gov/opprd001/inerts/index.html):

- List 1 – Inert Ingredients of Toxicological Concern;
- List 2 – Potentially Toxic Inert Ingredients;
- List 3 – Inerts of Unknown Toxicity; and
- List 4 – Inerts of Minimal Toxicity.

Several of the List 4 compounds are naturally-occurring earthen materials (e.g., clay materials, simple salts) that would not elicit toxicological response at applied concentrations. However, some of the inerts (particularly the List 3 compounds and unlisted compounds) may have moderate to high toxicity to aquatic species based on MSDSs or published data.

Comprehensively assessing potential effects of pesticide use to non-target fish, wildlife, plants, and/or their habitats is a complex task. It would be preferable to assess the cumulative effects from exposure to the active ingredient, its degradates, and inert ingredients as well as other active ingredients in the spray mixture. However, it would only be feasible to conduct deterministic risk assessments for each component in the spray mixture singly. Limited scientific information is available regarding ecological effects (additive or synergistic) from chemical mixtures and these assessments typically rely upon broad assumptions. For example, the U.S.

Forest Service (2005) found that mixtures of pesticides used in land (forest) management likely would not cause additive or synergistic effects to non-target species based upon a review of scientific literature regarding toxicological effects and interactions of agricultural chemicals (ATSDR, 2004). Moreover, information on inert ingredients, adjuvants, and degradates is often limited by the availability of and access to reliable toxicological data for these constituents.

Toxicological information regarding "other ingredients" may be available from sources such as the following:

- TOMES (a proprietary toxicological database including USEPA's IRIS, the Hazardous Substance Data Bank, and the Registry of Toxic Effects of Chemical Substances [RTECS]).
- USEPA's ECOTOX database, which includes AQUIRE (a database containing scientific papers published on the toxic effects of chemicals to aquatic organisms).
- TOXLINE (a literature searching tool).
- Material Safety Data Sheets (MSDSs) from pesticide suppliers.
- Other sources such as the Farm Chemicals Handbook.

Due to the paucity of specific toxicological data regarding inerts, it is unknown whether they may cause adverse ecological effects. However, inert ingredients typically represent only a small percentage of the pesticide spray mixture and it is expected that their use results in negligible effects.

Although the potential effects of degradates should be considered when selecting a pesticide, it is beyond the scope of this assessment process to consider all possible breakdown chemicals of the various product formulations containing an active ingredient. Degradates may be more or less mobile and more or less hazardous in the environment than their parent pesticides (Battaglin et al., 2003). Differences in environmental behavior (e.g., mobility) and toxicity between parent pesticides and degradates make assessing potential degradate effects extremely difficult. For example, a less toxic and more mobile, bioaccumulative, or persistent degradate may have potentially greater effects on species and/or degrade environmental quality. The lack of data on the toxicity of degradates for many pesticides represents a source of uncertainty for assessing risk.

A USEPA-approved label specifies whether a product can be mixed with one or more pesticides. Without product-specific toxicological data, it is not possible to quantify the potential effects of these mixtures. In addition, a quantitative analysis can only be conducted if reliable scientific information allows a determination of whether the joint action of a mixture is additive, synergistic, or antagonistic. Such information would not likely exist unless the mode of action would be common among the chemicals and receptors. Moreover, the composition of and exposure to mixtures can be highly site- and/or time-specific and, therefore, it is nearly impossible to assess potential effects to species and environmental quality.

Applying pesticides in accordance with labeling requirements minimizes or eliminates potential negative effects associated with applying two or more pesticides as a mixture. Labels for two or more pesticides applied as a mixture should be completely reviewed and products with the least potential for negative effects should be selected for use on a refuge. This is especially relevant when a mixture is to be applied in a manner that may already have the potential for an effect(s) associated with an individual pesticide (e.g., runoff to ponds in sandy watersheds). Use of a tank mix under these conditions increases the level of uncertainty in terms of risk to species or potential to degrade environmental quality.

Adjuvants generally function to enhance or prolong pesticide activity. For terrestrial herbicides, adjuvants aid in the absorption into plant tissue. Adjuvant is a broad term that generally applies to surfactants, selected oils, anti-foaming agents, buffering compounds, drift control agents, compatibility agents, stickers, and spreaders. Adjuvants are not under the same registration requirements as pesticides and the USEPA does not register or approve the labeling of spray adjuvants. Individual labels identify types of adjuvants approved for use with the particular pesticide. In general, adjuvants compose a relatively small portion of the volume of pesticides applied. To reduce the potential for the adjuvant to influence the toxicity of the pesticide, adjuvants with limited toxicity and low volumes should be selected.

7.4 Determining Effects to Soil and Water Quality

The approval process for pesticide uses considers the potential to degrade water quality on and off refuge lands. A pesticide can only affect water quality through movement away from the treatment site. After application, pesticide mobilization can be characterized by one or more of the following (Kerle et al. 1996):

- Attach (sorb) to soil, vegetation, or other surfaces and remain at or near the treated area;
- Attach to soil and move off-site through erosion from runoff or wind; and
- Dissolve in water that can be subjected to runoff or leaching.

As an initial screening tool, selected chemical characteristics and rating criteria for a pesticide can be evaluated to assess potential to enter ground and/or surface waters. These include persistence, sorption coefficient (K_{oc}), groundwater ubiquity score (GUS), and solubility.

Persistence, which is expressed as half-life ($t_{½}$), represents the length of time required for 50% of the deposited pesticide to degrade (completely or partially). Persistence in the soil can be categorized as the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et al., 1996). Half-life data are usually available for aquatic and terrestrial environments.

Another measure of pesticide persistence is dissipation time (DT_{50}). It represents the time required for 50% of the deposited pesticide to degrade and move from a treated site; whereas, half-life describes the rate for degradation only. As for half-life, units of dissipation time are usually expressed in days. Field or foliar dissipation time is the preferred measure for estimating pesticide concentrations in the environment. However, soil half-life is the most common persistence measure cited in published literature. If field or foliar dissipation data are not available, soil half-life data may be used. The average or representative half-life value of most important degradation mechanism will be selected for quantitative analysis for both terrestrial and aquatic environments.

Mobility of a pesticide is a function of how strongly it is adsorbed to soil particles and organic matter, its solubility in water, and its persistence in the environment. Pesticides strongly adsorbed to soil particles, relatively insoluble in water, and not environmentally persistent are less likely to move across the soil surface into surface waters or to leach through the soil profile and contaminate groundwater. Conversely, pesticides that are not strongly adsorbed to soil particles, are highly water soluble, and are persistent in the environment have greater potential to move from the application site (off-site movement).

The degree of pesticide adsorption to soil particles and organic matter (Kerle et al., 1996) is expressed as the soil adsorption coefficient (K_{oc}). The soil adsorption coefficient is measured as micrograms of pesticide per gram of soil (µg/g) and can range from near zero to the thousands. Pesticides with higher K_{oc} values are strongly sorbed to soil and, therefore, less subject to movement.

Water solubility describes the degree to which a pesticide will dissolve in a known quantity of water. The water solubility of a pesticide is expressed as milligrams of pesticide dissolved in a liter of water (mg/L or parts per million [ppm]). Pesticide with solubility <0.1 ppm are virtually insoluble in water, 100-1000 ppm are moderately soluble, and >10,000 ppm highly soluble (USGS, 2000). As pesticide solubility increases, there is greater potential for off-site movement through runoff or leaching.

The Groundwater Ubiquity Score (GUS) is a quantitative screening tool to estimate a pesticide's potential to move in the environment. It utilizes soil persistence and adsorption coefficients in the following formula.

$$GUS = \log_{10}(t_{½}) \times [4 - \log_{10}(K_{oc})]$$

The potential pesticide movement rating is based upon its GUS value. Pesticides with a GUS <0.1 are considered to have an extremely low potential to move toward groundwater. Those with values of 1.0-2.0 are low, 2.0-3.0 are moderate, 3.0-4.0 are high, and >4.0 have a very high potential to move toward groundwater.

GUS, water solubility, $t_{½}$, and K_{oc} values are available for selected pesticides from the OSU Extension Pesticide Properties Database at http://npic.orst.edu/ppdmove.htm. Many of the values in this database were derived from the SCS/ARS/CES Pesticide Properties Database for Environmental Decision Making (Wauchope et al., 1992).

Soil properties influence the fate of pesticides in the environment. The following six properties are mostly likely to affect pesticide degradation and the potential for pesticides to move off-site by leaching (vertical movement through the soil) or runoff (lateral movement across the soil surface).

- Permeability is the rate of water movement vertically through the soil. It is affected by soil texture and structure. Coarse textured soils (e.g., those with a high sand content) have a larger pore size and are generally more permeable than fine textured soils (i.e., those with a high clay content). More permeable soils have a greater potential for pesticides to move vertically down through the soil profile. Soil permeability rates (inches/hour) are usually available in county soil survey reports.

- Soil texture describes the relative percentage of sand, silt, and clay. In general, greater clay content with smaller pore size lowers the likelihood and rate water moves through the soil profile. Clay also serves to adsorb (bind) pesticides to soil particles. Soils with high clay content adsorb more pesticide than soils with relatively low clay content. In contrast, sandy soils with coarser texture and lower water holding capacity have a greater potential for water to leach through them.
- Soil structure describes soil aggregation. Soils with a well-developed soil structure have looser, more aggregated, structure that is less likely to be compacted. Both characteristics allow for less restricted flow of water through the soil profile resulting in greater infiltration.
- Organic matter is the single most important factor affecting pesticide adsorption in soils. Many pesticides are adsorbed to organic matter which reduces their rate of downward movement through the soil profile. Also, soils high in organic matter tend to hold more water, which may make less water available for leaching.
- Soil moisture affects how fast water moves through the soil. If soils are already wet or saturated before rainfall or irrigation, excess moisture can run off rather than infiltrate into the soil profile. Soil moisture also influences microbial and chemical activity in soil, which affects pesticide degradation.
- Soil pH influences chemical reactions that occur in the soil which in turn determines whether or not a pesticide degrades, the rate of degradation, and, in some instances, which degradation products are produced.

Based upon the aforementioned properties, soils most vulnerable to groundwater contamination are sandy soils with low organic matter. In contrast, the least vulnerable soils are well-drained clayey soils with high organic matter. Consequently, pesticides with the lowest potential for movement in conjunction with appropriate best management practices (see below) should be used in an IPM framework to treat pests while minimizing effects to non-target biota and protecting environmental quality.

Along with soil properties, site-specific environmental and abiotic conditions (including rainfall, water table conditions, and topography) help determine the potential for a pesticide to affect water quality through runoff and leaching (Huddleston, 1996).

- Water is necessary to separate pesticides from soil. This can occur in two ways. Pesticides that are soluble move easily with runoff water., and pesticide-laden soil particles can be dislodged and transported from the application site in runoff. The concentration of pesticides in surface runoff is greatest for the first runoff event following treatment. The rainfall intensity and route of water infiltration into soil, to a large extent, determine pesticide concentrations and losses in surface runoff. The timing of the rainfall after application also can have an effect. Rainfall interacts with pesticides at a shallow soil depth (¼ to ½ inch), which is called the mixing zone (Baker and Miller 1999). The pesticide/water mixture in the mixing zone tends to leach down into the soil or run off, depending upon how quickly the soil surface becomes saturated and how rapidly water can infiltrate into the soil. Leaching decreases the amount of pesticide available near the soil surface (mixing zone) to run off during the initial and subsequent rainfall events following application.
- Terrain slope affects the potential for surface runoff and the intensity of runoff. Steeper slopes have greater potential for runoff following a rainfall event. In contrast, soils that are relatively flat have little potential for runoff, except during intense rainfall events. In

addition, soils in lower areas are more susceptible to leaching as a result of receiving excessive water from surrounding higher elevations.

- Depth to the water table is an important factor affecting the potential for pesticides to leach into groundwater. If the distance from the soil surface to the top of the water table is shallow, pesticides have less distance to travel to reach groundwater. Shallower water tables that persist for longer periods would be more likely to experience groundwater contamination. Soil survey reports are available for individual counties. These reports provide data in tabular format regarding water table depths and the months during which it persists. In some situations, a hard pan exists above the water table that prevents pesticide contamination from leaching.

7.5 Determining Effects to Air Quality

Pesticides may volatilize from soil and plant surfaces and move from the treated area into the atmosphere. The potential for a pesticide to volatilize is determined by the pesticide's vapor pressure which is affected by temperature, sorption, soil moisture, and the pesticide's water solubility. Vapor pressure is often expressed in mm Hg. To make these numbers easier to compare, vapor pressure may be expressed in exponent form ($I \times 10^{-7}$), where I represents a vapor pressure index. In general, pesticides with $I<10$ would have a low potential to volatilize; whereas, pesticides with $I>1{,}000$ would have a high potential to volatilize (OSU, 1996). Vapor pressure values for pesticides are usually available in the pesticide product MSDS or the USDA Agricultural Research Service (ARS) pesticide database.

7.6 Preparing a Chemical Profile

The following instructions are used by Service personnel to complete Chemical Profiles for pesticides. Specifically, profiles are prepared for pesticide active ingredients (e.g., glyphosate and imazapic) that are contained in one or more trade name products registered and labeled with USEPA. All information fields under each category (e.g., Toxicological Endpoints and Environmental Fate) are included in a Chemical Profile. If no information is available for a specific field, then "No data is available in references" is recorded in the profile. Available scientific information is then used to complete Chemical Profiles. Each entry of scientific information is coupled with applicable references.

Completed Chemical Profiles provide a structured decision-making process utilizing quantitative assessment/screening tools with threshold values (where appropriate) that are used to evaluate potential biological and other environmental effects on refuge resources. For ecological risk assessments presented in these profiles, the "worst-case scenario" is evaluated to determine whether a pesticide could be approved for use considering the maximum single application rate specified on pesticide labels for habitat management and croplands/facilities maintenance treatments pertaining to refuges. Where the "worst-case scenario" likely would only result in minor, temporary, and localized effects to listed and non-listed species with appropriate BMPs (see Section 5.0), the proposed pesticide's use in a PUP would have a scientific basis for approval under any application rate specified on the label that is at or below rates evaluated in a Chemical Profile. In some cases, the Chemical Profile includes a lower application rate than the maximum labeled rate in order to protect refuge resources. As necessary, Chemical Profiles are periodically updated with new scientific information or as pesticides with the same active ingredient are proposed for use on the refuge in PUPs.

Throughout this section, threshold values (to prevent or minimize potential biological and environmental effects) are clearly identified for specific information presented in a completed Chemical Profile. Comparison with these threshold values provides an explicit scientific basis to approve or disapprove PUPs for habitat management and cropland/facilities maintenance on refuge lands. In general, PUPs are approved for pesticides with Chemical Profiles where there would be no exceedances of threshold values. However, BMPs are identified for some screening tools that would minimize/eliminate potential effects (exceedance of the threshold value) as a basis for approving PUPs.

Date: Service personnel record the date when the Chemical Profile is completed or updated. Chemical Profiles (e.g., currently approved pesticide use patterns) are periodically reviewed and updated, as necessary. The most recent review date id recorded on a profile to document when it was last updated.

Trade Name(s): Service personnel accurately and completely record the trade name(s) from the pesticide label, which includes a suffix that describes the formulation (e.g., WP, DG, EC, L, SP, I, II or 64). The suffix often distinguishes a specific product among several pesticides with the same active ingredient. Service personnel record a trade name for each pesticide product with the same active ingredient.

Common chemical name(s): Service personnel record the common name(s) listed on the pesticide label or material safety data sheet (MSDS) for each active ingredient. The common name of a pesticide is listed as the active ingredient on the title page of the product label immediately following the trade name, and the MSDS, Section 2: Composition/ Information on Ingredients. A Chemical Profile is completed for each active ingredient.

Pesticide Type: Service personnel record the type of pesticide for an active ingredient as one of the following: herbicide, desiccant, fungicide, fumigant, growth regulator, insecticide, piscicide, or rodenticide.

EPA Registration Number(s): This number (EPA Reg. No.) appears on the title page of the label and MSDS, Section 1: Chemical Product and Company Description. It is not the EPA Establishment Number that is usually located near it. Service personnel record the EPA Reg. No. for each trade name product with an active ingredient based upon PUPs.

Pesticide Class: Service personnel list the general chemical class for the pesticide (active ingredient). For example, malathion is an organophosphate and carbaryl is a carbamate.

CAS (Chemical Abstract Service) Number: This number is often located in the second section (Composition/Information on Ingredients) of the MSDS. The MSDS table listing components usually contains this number immediately prior to or following the % composition.

Other Ingredients: From the most recent MSDS for the proposed pesticide product(s), Service personnel include any chemicals in the pesticide formulation not listed as an active ingredient that are described as toxic or hazardous, or regulated under the Superfund Amendments and Reauthorization Act (SARA); Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); Toxic Substances Control Act (TSCA); Occupational Safety and Health Administration (OSHA); State Right-to-Know; or other listed authorities. These are usually found in MSDS sections titled “Hazardous Identifications,” “Exposure Control/Personal Protection,” and “Regulatory Information.” If concentrations of other ingredients are available for any compounds identified as toxic or hazardous, then Service personnel record this information in the Chemical Profile by trade name. MSDS(s) may be obtained from the manufacturer, manufacturer’s website, or from an on-line database maintained by Crop Data Management Systems, Inc. (see list below).

Toxicological Endpoints

Toxicological endpoint data are collected for acute and chronic tests with mammals, birds, and fish. Data are recorded for species available in the scientific literature. If no data are found for a particular taxonomic group, then “No data available in references” is recorded as the data entry. Throughout the Chemical Profile, references (including for toxicological endpoint data) are cited using parentheses (#) following the recorded data.

Mammalian LD_{50}: For test species in the scientific literature, Service personnel records available data for oral lethal dose (LD_{50}) in mg/kg-bw (body weight) or ppm-bw. Most common test species in scientific literature are the rat and mouse. The lowest LD_{50} value found for a rat is used as a toxicological endpoint for dose-based RQ calculations to assess acute risk to mammals (see Table 1 in Section 7.1).

Mammalian LC_{50}: For test species in the scientific literature, Service personnel record available data for dietary lethal concentration (LC_{50}) as reported (e.g., mg/kg-diet or ppm-diet). Most common test species in scientific literature are the rat and mouse. The lowest LC_{50} value found for a rat is used as a toxicological endpoint for diet-based RQ calculations to assess acute risk (see Table 1 in Section 7.1).

Mammalian Reproduction: For test species listed in the scientific literature, Service personnel record the test results (e.g., Lowest Observed Effect Concentration [LOEC], Lowest Observed Effect Level [LOEL], No Observed Adverse Effect Level [NOAEL], No Observed Adverse Effect Concentration [NOAEC]) in mg/kg-bw or mg/kg-diet for reproductive test procedure(s) (e.g., generational studies [preferred], fertility, new born weight). Most common test species available in scientific literature are rats and mice. The lowest NOEC, NOAEC, NOEL, or NOAEL test results found for a rat are used as a toxicological endpoint for RQ calculations to assess chronic risk (see Table 1 in Section 7.1).

Avian LD_{50}: For test species available in the scientific literature, Service personnel record values for oral lethal dose (LD_{50}) in mg/kg-bw or ppm-bw. Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest LD_{50} value found for an avian species is used as a toxicological endpoint for dose-based RQ calculations to assess acute risk (see Table 1 in Section 7.1).

Avian LC_{50}: For test species available in the scientific literature, Service personnel record values for dietary lethal concentration (LC_{50}) as reported (e.g., mg/kg-diet or ppm-diet). Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest LC_{50} value found for an avian species is used as a toxicological endpoint for dietary-based RQ calculations to assess acute risk (see Table 1 in Section 7.1).

Avian Reproduction: For test species available in the scientific literature, Service personnel record test results (e.g., LOEC, LOEL, NOAEC, NOAEL) in mg/kg-bw or mg/kg-diet consumed for reproductive test procedure(s) (e.g., early life cycle, reproductive). Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest NOEC, NOAEC, NOEL, or NOAEL test results found for an avian species is used as a toxicological endpoint for RQ calculations to assess chronic risk (see Table 1 in Section 7.1).

Fish LC_{50}: For test freshwater or marine species listed in the scientific literature, Service personnel record an LC_{50} in ppm or mg/L. Most common test species available in the scientific literature are the bluegill, rainbow trout, and fathead minnow (marine). Test results for many game species may also be available. The lowest LC_{50} value found for a freshwater fish species is used as a toxicological endpoint for RQ calculations to assess acute risk (see Table 1 in Section 7.1).

Fish Early Life Stage (ELS)/Life Cycle: For test freshwater or marine species available in the scientific literature, Service personnel record test results (e.g., LOEC, NOAEL, NOAEC, LOAEC) in ppm for test procedure(s) (e.g., early life cycle, life cycle). Most common test species available in the scientific literature are bluegill, rainbow trout, and fathead minnow. Test results for other game species may also be available. The lowest test value found for a fish species (preferably freshwater) is used as a toxicological endpoint for RQ calculations to assess chronic risk (see Table 1 in Section 7.1).

Other: For test invertebrate as well as non-vascular and vascular plant species available in the scientific literature, Service personnel record $LC_{50,}$ $LD_{50,}$ LOEC, LOEL, NOAEC, NOAEL, or EC_{50} (environmental concentration) values in ppm or mg/L. Most common test invertebrate species available in scientific literature are the honey bee and the water flea (*Daphnia magna*). Green algae (*Selenastrum capricornutum*) and pondweed (*Lemna minor*) are frequently available test species for aquatic non-vascular and vascular plants, respectively.

Ecological Incident Reports: After a site has been treated with pesticide(s), wildlife can be exposed to these chemical(s). When exposure is high relative to the toxicity of the pesticides, wildlife can be killed or visibly harmed (incapacitated). Such events are called ecological incidents. The USEPA maintains a database (Ecological Incident Information System) of ecological incidents. This database stores information extracted from incident reports submitted by various federal and state agencies and non-government organizations. Information included in an incident report is date and location of the incident, type and magnitude of effects observed in various species, use(s) of pesticides known or suspected of contributing to the incident, and results of any chemical residue and cholinesterase activity analyses conducted during the investigation.

Incident reports can play an important role in evaluating the effects of pesticides by supplementing quantitative risk assessments. All incident reports for pesticide(s) with the active ingredient and associated information would be recorded.

Environmental Fate

Water Solubility: Service personnel record values for water solubility (S_w), which describes the amount of pesticide that dissolves in a known quantity of water. S_w is expressed as mg/L (ppm). Pesticide S_w values are categorized as one of the following: insoluble <0.1 ppm, moderately soluble = 100 to 1000 ppm, highly soluble >10,000 ppm (USGS, 2000). As pesticide S_w increases, there is greater potential to degrade water quality through runoff and leaching. Sw is used to evaluate potential for bioaccumulation in aquatic species [see **Octanol-Water Partition Coefficient (K_{ow})** below].

Soil Mobility: Service personnel record available values for soil adsorption coefficient (K_{oc} [μg/g]). This value provides a measure of a chemical's mobility and leaching potential in soil. K_{oc} values are directly proportional to organic content, clay content, and surface area of the soil. K_{oc} data for a pesticide may be available for a variety of soil types (e.g., clay, loam, sand). K_{oc} values are used in evaluating the potential to degrade groundwater by leaching (see **Potential to Move to Groundwater** below).

Soil Persistence: Service personnel record values for soil half-life ($t_{½}$), which represents the length of time (days) required for 50% of the deposited pesticide to degrade (completely or partially) in the soil. Based upon the $t_{½}$ value, soil persistence is categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et al., 1996).

Threshold for Approving PUPs:
If soil $t_{½}$ ≤100 days, then a PUP can be approved without additional BMPs to protect water quality. If soil $t_{½}$ >100 days, then a PUP can only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following are included in the **Specific Best Management Practices (BMPs) section** *to minimize potential surface runoff and leaching that can degrade water quality.*

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Along with K_{oc}, soil $t_{½}$ values are used in evaluating the potential to degrade groundwater by leaching (see **Potential to Move to Groundwater** below).

Soil Dissipation: Dissipation time (DT_{50}) represents the time required for 50% of the deposited pesticide to degrade and move from a treated site; whereas, soil $t_{½}$ describes the rate for degradation only. As for $t_{½}$, units of dissipation time are usually expressed in days. Field dissipation times are the preferred data for use to estimate pesticide concentrations in the environment because they are based upon field studies, compared to soil $t_{½}$, which is derived in a laboratory. However, soil $t_{½}$ are the most common persistence data available in the published literature. If field dissipation data are not available, soil half-life data are used in a Chemical Profile. The average or representative half-life value of the most important degradation mechanism is selected for quantitative analysis for both terrestrial and aquatic environments.

Based upon the DT_{50} value, environmental persistence in the soil is categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days.

Threshold for Approving PUPs:
If soil DT_{50} ≤100 days, then a PUP can be approved without additional BMPs to protect water quality. If soil DT_{50} >100 days, then a PUP can only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following are included in the **Specific Best Management Practices (BMPs) section** *to minimize potential surface runoff and leaching that can degrade water quality.*

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Along with K_{oc}, soil DT_{50} values (preferred over soil $t_{½}$) are used in evaluating the potential to degrade groundwater by leaching (see **Potential to Move to Groundwater** below), if available.

Aquatic Persistence: Service personnel record values for aquatic $t_{½}$, which represents the length of time required for 50% of the deposited pesticide to degrade (completely or partially) in water. Based upon the $t_{½}$ value, aquatic persistence is categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et. al. 1996).

Threshold for Approving PUPs:
If aquatic $t_{½}$ ≤100 days, then a PUP can be approved without additional BMPs to protect water quality. If aquatic $t_{½}$ >100 days, then a PUP can only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following are included in the **Specific Best Management Practices (BMPs) section** *to minimize potential surface runoff and leaching that can degrade water quality.*

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Aquatic Dissipation: Dissipation time (DT_{50}) represents the time required for 50% of the deposited pesticide to degrade or move (dissipate); whereas, aquatic $t_{½}$ describes the rate for degradation only. As for $t_{½}$, units of dissipation time are usually expressed in days. Based upon the DT_{50} value, environmental persistence in aquatic habitats is categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days.

Threshold for Approving PUPs:
If aquatic $DT_{50} \leq 100$ days, then a PUP can be approved without additional BMPs to protect water quality. If aquatic $DT_{50} > 100$ days, then a PUP can only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following is included in the **Specific Best Management Practices (BMPs) section** *to minimize potential surface runoff and leaching that can degrade water quality.*

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Potential to Move to Groundwater: Groundwater Ubiquity Score (GUS) = $\log_{10}(\text{soil } t_{½}) \times [4 - \log_{10}(K_{oc})]$. If a DT_{50} value is available, it is used rather than a $t_{½}$ value to calculate a GUS score. Based upon the GUS value, the potential to move toward groundwater is recorded as one of the following categories: extremely low potential<1.0, low - 1.0 to 2.0, moderate - 2.0 to 3.0, high - 3.0 to 4.0, or very high>4.0.

Threshold for Approving PUPs:
If GUS ≤4.0, then a PUP can be approved without additional BMPs to protect water quality. If GUS >4.0, then a PUP can only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following is included in the **Specific Best Management Practices (BMPs) section** *to minimize potential surface runoff and leaching that can degrade water quality.*

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Volatilization: Pesticides may volatilize (evaporate) from soil and plant surfaces and move off-target into the atmosphere. The potential for a pesticide to volatilize is a function of its vapor pressure that is affected by temperature, sorption, soil moisture, and the pesticide's water solubility. Vapor pressure is often expressed in mm Hg. To make these values easier to compare, vapor pressure is recorded by Service personnel in exponential form ($I \times 10^{-7}$), where I represents a vapor pressure index. In general, pesticides with I<10 have low potential to volatilize; whereas, pesticides with I >1,000 have a high potential to volatilize (OSU, 1996). Vapor pressure values for pesticides are usually available in the pesticide product MSDS or the USDA Agricultural Research Service (ARS) pesticide database (see **References**).

Threshold for Approving PUPs:
If I ≤1,000, then a PUP can be approved without additional BMPs to minimize drift and protect air quality. If I >1,000, then a PUP can only be approved with additional BMPs specifically to minimize drift and protect air quality. One or more BMPs such as the following is included in the **Specific Best Management Practices (BMPs) section** *to reduce volatilization and potential to drift and degrade air quality.*

- *Do not treat when wind velocities are <2 or >10 mph with existing or potential inversion conditions.*
- *Apply the largest-diameter droplets possible for spray treatments.*
- *Avoid spraying when air temperatures >85^{o}F.*
- *Use the lowest spray height possible above target canopy.*
- *Where identified on the pesticide label, soil incorporate pesticide as soon as possible during or after application.*

Octanol-Water Partition Coefficient (K_{ow}): The octanol-water partition coefficient (K_{ow}) is the concentration of a pesticide in octanol and water at equilibrium at a specific temperature. Because octanol is an organic solvent, it is considered a surrogate for natural organic matter. Therefore, K_{ow} is used to assess potential for a pesticide to bioaccumulate in tissues of aquatic species (e.g., fish). If K_{ow} >1,000 or S_w<1 mg/L and soil $t_{½}$>30 days, then there is high potential for a pesticide to bioaccumulate in aquatic species such as fish (USGS, 2000).

Threshold for Approving PUPs:
If there is not a high potential for a pesticide to bioaccumulate in aquatic species, then the PUP can be approved.
If there is a high potential to bioaccumulate in aquatic species (K_{ow}>1,000 or S_w<1 mg/L and soil $t_{½}$>30 days), then the PUP cannot approved, except under unusual circumstances where approval is granted by the Washington Office.

Bioaccumulation/Bioconcentration: The physiological process where pesticide concentrations in tissue would increase in biota because they are taken and stored at a faster rate than they are metabolized or excreted. The potential for bioaccumulation is evaluated through bioaccumulation factors (BAFs) or bioconcentration factors (BCFs). Based upon BAF or BCF values, the potential to bioaccumulate is recorded as one of the following: low – 0 to 300, moderate – 300 to 1,000, or high >1,000 (Calabrese and Baldwin, 1993).

Threshold for Approving PUPs:
If BAF or BCF≤1,000, then a PUP can be approved without additional BMPs.
If BAF or BCF>1,000, then a PUP cannot approved, except under unusual circumstances where approval is granted by the Washington Office.

Worst-Case Ecological Risk Assessment

Max Application Rates (acid equivalent): Service personnel record the highest application rate of an active ingredient (ae basis) for habitat management and cropland/facilities maintenance treatments in this data field of a Chemical Profile. These rates can be found in Table CP.1 under the column heading "Max Product Rate – Single Application (lbs/acre – AI on acid equiv basis)." This table is prepared for a Chemical Profile from information specified in labels for trade name products identified in PUPs. If these data are not available in pesticide labels, then "NS" for "not specified is written on label" in this table.

EECs: An estimated environmental concentration (ECC) represents potential exposure to fish and wildlife (birds and mammals) from using a pesticide. EECs are derived by Service personnel using an USEPA screening-level approach (USEPA, 2004). For each maximum application rate [see description under **Max Application Rates (acid equivalent)**], Service personnel record 2 EEC values in a Chemical Profile; these represent the worst-case terrestrial and aquatic exposures for habitat management and croplands/facilities maintenance treatments. For terrestrial and aquatic EEC calculations, see description for data entry under **Presumption of Unacceptable Risk/Risk Quotients**, which is the next field for a Chemical Profile.

Presumption of Unacceptable Risk/Risk Quotients: Service personnel calculate and record acute and chronic risk quotients (RQs) for birds, mammals, and fish using the provided tabular formats for habitat management and/or cropland/facilities maintenance treatments. RQs recorded in a Chemical Profile would the worst-case assessment for ecological risk. See Section 7.2 for discussion regarding the calculations of RQs.

For aquatic assessments associated with habitat management treatments, RQ calculations are based upon selected acute and chronic toxicological endpoints for fish and the EEC is derived from Urban and Cook (1986) assuming 100% overspray to an entire 1-foot deep water body using the maximum application rate (ae basis [see above]).

For aquatic assessments associated with cropland/facilities maintenance treatments, RQ calculations are done by Service personnel based upon selected acute and chronic toxicological endpoints for fish and an EEC is derived from the aquatic assessment in AgDRIFT® model version 2.01 under Tier I ground-based application with the following input variables: max application rate (acid basis [see above]), low boom (20 inches), fine to medium/coarse droplet size, 20 swaths, EPA-defined wetland, and 25-foot distance (buffer) from treated area to water. See Section 7.2.1.2 for more details regarding the calculation of EECs for aquatic habitats for habitat management and cropland/facilities maintenance treatments.

For terrestrial avian and mammalian assessments, RQ calculations are done by Service personnel based upon dietary exposure, where the "short grass" food item category represents the worst-case scenario. For terrestrial spray applications associated with habitat management and cropland/facilities maintenance treatments, exposure (EECs and RQs) is determined using the Kanaga nomogram method through the USEPA's T-REX version 1.2.3. T-REX input variables include the following: max application rate (acid basis [see above]) and pesticide half-life (days) in soil to estimate the initial, maximum pesticide residue concentration on general food items for terrestrial vertebrate species in short (<20 cm tall) grass. For granular pesticide formulations and pesticide-treated seed with a unique route of exposure for terrestrial avian and mammalian wildlife, see Section 7.2.1.1.2 for the procedure that is used to calculate RQs.

All calculated RQs in both tables are compared with Levels of Concern (LOCs) established by USEPA (see Table 2 in Section 7.2). If a calculated RQ exceeds an established LOC value (in brackets inside the table), then there is a potential for an acute or chronic effect (unacceptable risk) to federally listed (T&E) species and non-listed species. See Section 7.2 for detailed descriptions of acute and chronic RQ calculations and comparison to LOCs to assess risk.

Threshold for approving PUPs:
If RQs≤LOCs, then a PUP can be approved without additional BMPs. If RQs>LOCs, then a PUP can only be approved with additional BMPs specifically to minimize exposure (ecological risk) to bird, mammal, and/or fish species. One or more BMPs such as the following is included in the **Specific Best Management Practices (BMPs) section** *to reduce potential risk to non-listed or listed species.*

- *Lower application rate and/or fewer number of applications so RQs≤LOCs.*
- *For aquatic assessments (fish) associated with cropland/facilities maintenance, increase the buffer distance beyond 25 feet so RQs≤LOCs.*

Justification for Use: Service personnel describe the reason for using the pesticide-based control of specific pests or groups of pests. In most cases, the pesticide label will provide the appropriate information regarding control of pests to describe in the section.

Specific Best Management Practices (BMPs): Service personnel record specific BMPs necessary to minimize or eliminate potential effects to non-target species and/or degradation of environmental quality from drift, surface runoff, or leaching. These BMPs are based upon scientific information documented in previous data fields of a Chemical Profile. Where necessary and feasible, these specific practices are included in PUPs as a basis for approval.

If there are no specific BMPs that are appropriate, then Service personnel describe why the potential effects to refuge resources and/or degradation of environmental quality is outweighed by the overall resource benefit(s) from the proposed pesticide use in the BMP section of the PUP. See Section 4.0 of this document for a complete list of BMPs associated with mixing and applying pesticides appropriate for all PUPs with ground-based treatments that would be additive to any necessary, chemical-specific BMPs.

References: Service personnel record scientific resources used to provide data/information for a chemical profile. Use the number sequence to uniquely reference data in a chemical profile.

The following on-line data resources are readily available for toxicological endpoint and environmental fate data for pesticides.

1. California Product/Label Database. Department of Pesticide Regulation, California Environmental Protection Agency. (http://www.cdpr.ca.gov/docs/label/labelque.htm#regprods)

2. ECOTOX database. Office of Pesticide Programs, US Environmental Protection Agency, Washington, DC. (http://cfpub.epa.gov/ecotox/)

3. Extension Toxicology Network (EXTOXNET) Pesticide Information Profiles. Cooperative effort of University of California-Davis, Oregon State University, Michigan State University, Cornell University and University of Idaho through Oregon State University, Corvallis, Oregon. (http://extoxnet.orst.edu/pips/ghindex.html)

4. FAO specifications and evaluations for plant protection products. Pesticide Management Unit, Plant Protection Services, Food and Agriculture Organization, United Nations. (http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/)

5. Human health and ecological risk assessments. Pesticide Management and Coordination, Forest Health Protection, US Department of Agriculture, US Forest Service. (http://www.fs.fed.us/foresthealth/pesticide/risk.htm)

6. Pesticide Chemical Fact Sheets. Clemson University Pesticide Information Center. (http://entweb.clemson.edu/pesticid/Document/Labels/factshee.htm)

7. Pesticide Fact Sheets. Published by Information Ventures, Inc. for Bureau of Land Management, Department of Interior; Bonneville Power Administration, U.S. Department of Energy; and Forest Service, US Department of Agriculture. (http://infoventures.com/e-hlth/pesticide/pest-fac.html)

8. Pesticide Fact Sheets. National Pesticide Information Center. (http://npic.orst.edu/npicfact.htm)

9. Pesticide Fate Database. US Environmental Protection Agency, Washington, DC. (http://cfpub.epa.gov/pfate/home.cfm).

10. Pesticide product labels and material safety data sheets. Crop Data Management Systems, Inc. (CDMS) (http://www.cdms.net/pfa/LUpdateMsg.asp) or multiple websites maintained by agrichemical companies.

11. Registered Pesticide Products (Oregon database). Oregon Department of Agriculture. (http://www.oda.state.or.us/dbs/pest_products/search.lasso)

12. Regulatory notes. Pest Management Regulatory Agency, Health Canada, Ontario, Canada. (http://www.hc-sc.gc.ca/pmra-arla/)

13. Reptile and Amphibian Toxicology Literature. Canadian Wildlife Service, Environment Canada, Ontario, Canada. (http://www.cws-scf.ec.gc.ca/nwrc-cnrf/ratl/index_e.cfm)

14. Specific Chemical Fact Sheet – New Active Ingredients, Biopesticide Fact Sheet and Registration Fact Sheet. U.S Environmental Protection Agency, Washington, DC. (http://www.epa.gov/pestidides/factsheets/chemical_fs.htm)

15. Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas. The Invasive Species Initiative. The Nature Conservancy. (http://tnsweeds.ucdavis.edu/handbook.html)

16. Wildlife Contaminants Online.US Geological Survey, Department of Interior, Washington, D.C. (http://www.pwrc.usgs.gov/contaminants-online/)

17. One-liner database. 2000. US Environmental Protection Agency, Office of Pesticide Programs, Washington, D.C.

Chemical Profile

Date:			
Trade Name(s):		**Common Chemical Name(s):**	
Pesticide Type:		**EPA Registration Number:**	
Pesticide Class:		**CAS Number:**	
Other Ingredients:			

Toxicological Endpoints

Mammalian LD_{50}:	
Mammalian LC_{50}:	
Mammalian Reproduction:	
Avian LD_{50}:	
Avian LC_{50}:	
Avian Reproduction:	
Fish LC_{50}:	
Fish ELS/Life Cycle:	
Other:	

Ecological Incident Reports

Environmental Fate

Water solubility (S_w):	
Soil Mobility (K_{oc}):	
Soil Persistence ($t_{½}$):	
Soil Dissipation (DT_{50}):	
Aquatic Persistence ($t_{½}$):	
Aquatic Dissipation (DT_{50}):	
Potential to Move to Groundwater (GUS score):	
Volatilization (mm Hg):	
Octanol-Water Partition Coefficient (K_{ow}):	
Bioaccumulation/Bioconcentration:	**BAF:`** **BCF:**

Worst Case Ecological Risk Assessment

Max Application Rate (ai lbs/acre – ae basis)	**Habitat Management:** **Croplands/Facilities Maintenance:**
EECs	**Terrestrial (Habitat Management):** **Terrestrial (Croplands/Facilities Maintenance):** **Aquatic (Habitat Management):** **Aquatic (Croplands/Facilities Maintenance):**

Habitat Management Treatments:

Presumption of Unacceptable Risk		**Risk Quotient (RQ)**	
		Listed (T&E) Species	**Non-listed Species**
Acute	Birds	[0.1]	[0.5]
	Mammals	[0.1]	[0.5]
	Fish	[0.05]	[0.5]
Chronic	Birds	[1]	[1]

	Mammals	[1]	[1]
	Fish	[1]	[1]

Cropland/Facilities Maintenance Treatments:

Presumption of Unacceptable Risk		**Risk Quotient (RQ)**	
		Listed (T&E) Species	**Non-listed Species**
Acute	Birds	[0.1]	[0.5]
	Mammals	[0.1]	[0.5]
	Fish	[0.05]	[0.5]
Chronic	Birds	[1]	[1]
	Mammals	[1]	[1]
	Fish	[1]	[1]

Justification for Use:	
Specific Best Management Practices (BMPs):	
References:	

Table CP.1 Pesticide Name

Trade Name[a]	Treatment Type[b]	Max Product Rate – Single Application (lbs/acre or gal/acre)	Max Product Rate - Single Application (lbs/acre - AI on acid equiv basis)	Max Number of Applications Per Season	Max Product Rate Per Season (lbs/acre/season or gal/acre/season)	Minimum Time Between Applications (Days)

[a]From each label for a pesticide identified in pesticide use proposals (PUPs), Service personnel would record application information associated with possible/known uses on Service lands.
[b]Treatment type: H – habitat management or CF – cropland/facilities maintenance. If a pesticide is labeled for both types of treatments (uses), then record separate data for H and CF applications.

7.0 References

AgDRIFT 2001. A user's guide for AgDRIFT 2.04: a tiered approach for the assessment of spray drift of pesticides. Spray Drift Task Force, PO Box 509, Macon, Missouri.

ATSDR (Agency for Toxic Substances and Disease Registry) US Department of Health and Human Services. 2004. Guidance Manual for the Assessment of Joint Toxic Action of Chemical Mixtures. U.S. Department of Health and Human Services, Public Health Service, ATSDR, Division of Toxicology. 62 pages plus Appendices.

Baehr, C.H., and C. Habig. 2000. Statistical evaluation of the UTAB database for use in terrestrial non-target organism risk assessment. 10th Symposium on Environmental Toxicology and Risk Assessment, American Society of Testing and Materials.

Baker, J. and G. Miller.1999. Understanding and reducing pesticide losses. Extension Publication PM 1495, Iowa State University Extension, Ames, Iowa. 6 pages.

Barry, T. 2004. Characterization of propanil prune foliage residues as related to propanil use patterns in the Sacramento Valley, CA. Proceedings of the International Conference on Pesticide Application for Drift Management. Waikoloa, Hawaii. 15 pages.

Battaglin, W.A., E.M. Thurman, S.J. Kalkhoff, and S.D. Porter. 2003. Herbicides and Transformation Products in Surface Waters of the Midwestern United States. Journal of the American Water Resources Association (JAWRA) 39(4):743-756.

Beyer, W.N., E.E. Connor, S. Gerould. 1994. Estimates of soil ingestion by wildlife. Journal of Wildlife Management 58:375-382.

Brooks, M.L., D'Antonio, C.M., Richardson, D.M., Grace, J.B., Keeley, J.E. and others. 2004. Effects of invasive alien plants on fire regimes. BioScience 54:77-88.

Butler, T., W. Martinkovic, and O.N. Nesheim. 1998. Factors influencing pesticide movement to ground water. Extension Publication PI-2, University of Florida, Cooperative Extension Service, Gainesville, FL. 4 pages.

Calabrese, E.J. and L.A. Baldwin. 1993. Performing Ecological Risk Assessments. Lewis Publishers, Chelsea, MI.

Center, T.D., Frank, J.H., and Dray Jr., F.A. 1997. Biological Control. Strangers in Paradise: Impact and Management of Nonindigenous Species in Florida. P.245-263.

Cox, R.D., and V.J. Anderson. 2004. Increasing native diversity of cheatgrass-dominated rangeland through assisted succession. Journal of Range Management 57:203-210.

Coombs, E.M., J.K Clark, G.L. Piper, and A.F. Cofrancesco Jr. 2004. Biological control of invasive plants in the United States. Oregon State University Press, Corvallis, 467 pages.

Driver, C.J., M.W. Ligotke, P. Van Voris, B.D. McVeety, B.J. Greenspan, and D.B. Brown. 1991. Routes of uptake and their relative contribution to the toxicologic response of northern bobwhite (*Colinus virginianus*) to an organophosphate pesticide. Environmental Toxicology and Chemistry 10:21-33.

Dunning, J.B. 1984. Body weights of 686 species of North American birds. Western Bird Banding Association. Monograph No. 1.

EXTOXNET. 1993a. Movement of pesticides in the environment. Pesticide Information Project of Cooperative Extension Offices of Cornell University, Oregon State University, University of Idaho, University of California – Davis, and the Institute for Environmental Toxicology, Michigan State University. 4 pages.

Fletcher, J.S., J.E. Nellessen, and T.G. Pfleeger. 1994. Literature review and evaluation of the EPA food-chain (Kenaga) nomogram, and instrument for estimating pesticide residue on plants. Environmental Toxicology and Chemistry 13:1381-1391.

Hasan, S. and P.G. Ayres. 1990. The control of weeds through fungi: principles and prospects. Tansley Review 23:201-222.

Huddleston, J.H. 1996. How soil properties affect groundwater vulnerability to pesticide contamination. EM 8559. Oregon State University Extension Service. 4 pages.

Kerle, E.A., J.J. Jenkins, P.A. Vogue. 1996. Understanding pesticide persistence and mobility for groundwater and surface water protection. EM 8561. Oregon State University Extension Service. 8 pages.

Masters, R.A, and R.L. Sheley. 2001. Invited synthesis paper: principles and practices for managing rangeland invasive plants. Journal of Range Manage 54:502-517.

Masters, R.A., S.J. Nissen, R.E. Gaussoin, D.D. Beran, and R.N. Stougaard. 1996. Imidazolinone herbicides improve restoration of Great Plains grasslands. Weed Technology 10:392-403.

Maxwell, B.D., E. Lehnhoff, L.J. Rew. 2009. The rationale for monitoring invasive plant populations as a crucial step for management. Invasive Plant Science and Management 2:1-9.

Mineau, P., B.T. Collins, and A. Baril. 1996. On the use of scaling factors to improve interspecies extrapolation to acute toxicity in birds. Regulatory Toxicology and Pharmacology 24:24-29.

Moody, M.E., and R.N. Mack. 1988. Controlling the spread of plant invasions: the importance of nascent foci. Journal of Applied Ecology 25:1009-1021.

Morse, L.E., J.M. Randall, N. Benton, R. Hiebert, and S. Lu. 2004. An Invasive Species Assessment Protocol: NatureServe.

Mullin, B.H., L.W. Anderson, J.M. DiTomaso, R.E. Eplee, and K.D. Getsinger. 2000. Invasive Plant Species. Issue Paper (13):1-18.

(OSU) Oregon State University. 1996. EXTOXNET-Extension Toxicology Network, Pesticide Information Profiles. Oregon State University, Corvallis, Oregon.

Pfleeger, T.G., A. Fong, R. Hayes, H. Ratsch, C. Wickliff. 1996. Field evaluation of the EPA (Kanaga) nomogram, a method for estimating wildlife exposure to pesticide residues on plants. Environmental Toxicology and Chemistry 15:535-543.

Pope, R., J. DeWitt, and J. Ellerhoff. 1999. Pesticide movement: what farmers need to know. Extension Publication PAT 36, Iowa State University Extension, Ames, Iowa and Iowa Department of Agriculture and Land Stewardship, Des Moines, Iowa. 6 pages.

Ramsay, C.A., G.C. Craig, and C.B. McConnell. 1995. Clean water for Washington – protecting groundwater from pesticide contamination. Extension Publication EB1644, Washington State University Extension, Pullman, Washington. 12 pages.

SDTF 2003 Spray Drift Task Force. 2003. A summary of chemigation application studies. Spray Drift Task Force, Macon, Missouri.

Teske, M.E., S.L. Bird, D.M. Esterly, S.L. Ray, S.G. and Perry. 1997. A User's Guide for AgDRIFT™ 1.0: A Tiered Approach for the Assessment of Spray Drift of Pesticides, Technical Note No. 95-10, CDI, Princeton, New Jersey.

Teske, M.E., S.L. Bird, D.M. Esterly, T.B. Curbishley, S.L. Ray, and S.G. Perry. 2002. AgDRIFT®: a model for estimating near-field spray drift from aerial applications. Environmental Toxicology and Chemistry 21: 659-671.

Urban, D.J and N.J. Cook. 1986. Ecological risk assessment. EPA 540/9-85-001. U.S. Environmental Protection Agency, Office of Pesticide Programs, Washington D.C. 94 pages.

(USBLM) U.S. Bureau of Land Management. 2007. Vegetation treatments using herbicides on Bureau of Land Management Lands in 17 western states Programmatic EIS (PEIS). Washington Office, Bureau of Land Management.

(USEPA) U.S. Environmental Protection Agency. 1990. Laboratory Test Methods of Exposure to Microbial Pest Control Agents by the Respiratory Route to Nontarget Avian Species. Environmental Research Laboratory, Corvallis, OR. EPA/600/3-90/070.

U.S. Environmental Protection Agency. 1998. A Comparative Analysis of Ecological Risks from Pesticides and Their Uses: Background, Methodology & Case Study. Environmental

Fate & Effects Division, Office of Pesticide Programs, U.S. Environmental Protection Agency, Washington, D.C. 105 pages.

U.S. Environmental Protection Agency. 2004. Overview of the ecological risk assessment process in the Office of Pesticide Programs, US Environmental Protection Agency: endangered and threatened species effects determinations, Office of Pesticide Programs, Washington, DC. 101 pages.

U.S. Environmental Protection Agency. 2005*a*. Technical overview of ecological risk assessment risk characterization; Approaches for evaluating exposure; Granular, bait, and treated seed applications. U.S. Environmental Protection Agency, Office of Pesticide Programs, Washington, DC. http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_exp.htm.

U.S. Environmental Protection Agency. 2005*b*. User's Guide TREX v1.2.3. U.S. Environmental Protection Agency, Office of Pesticide Programs, Washington, DC. 22 pages. http://www.epa.gov/oppefed1/models/terrestrial/trex_usersguide.htm.

(USGS) U.S. Geological Survey. 2000. Pesticides in stream sediment and aquatic biota – current understanding of distribution and major influences. USGS Fact Sheet 092-00, U.S. Geological Survey, Sacramento, California. 4 pages.

(USFS) U.S. Forest Service. 2005. Pacific Northwest Region Invasive Plant Program Preventing and Managing Invasive Plants Final Environmental Impact Statement. 359 pages.

Wauchope, R.D., T.M. Buttler, A.G. Hornsby, P.M. Augustijn-Beckers, and J.P. Burt. 1992. The SCS/ARS/CES pesticide properties database for environmental decision making. Reviews of Environmental Contamination and Toxicology 123:1-155.

Woods, N. 2004. Australian developments in spray drift management. Proceedings of the International Conference on Pesticide Application for Drift Management, Waikoloa, Hawaii. 8 pages.

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Appendix R – 1977 Cooperative Agreement between Fish and Wildlife Service and Bureau of Reclamation

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UNITED STATES OF AMERICA
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
and
BUREAU OF RECLAMATION

Contract No.
7-07-20-W0089

COOPERATIVE AGREEMENT

THIS COOPERATIVE AGREEMENT, made and entered into this 2nd day of August, 1977, by and between the FISH AND WILDLIFE SERVICE (hereinafter referred to as "the Service") and the BUREAU OF RECLAMATION (hereinafter referred to as "the Bureau"),

WITNESSETH:

WHEREAS, the Service and the Bureau entered into an agreement relating to the administration and control of the Tule Lake, Lower Klamath and Clear Lake Refuges, ch was approved on January 8, 1942; and

WHEREAS, said agreement was thereafter amended by a supplemental agreement between the Service and the Bureau approved on June 28, 1946; and

WHEREAS, on September 2, 1964, Congress enacted Pub. L. No. 88-567 (78 Stat. 85 16 U.S.C. § 695k *et seq.*), hereinafter referred to as "the Kuchel Act"; and

WHEREAS, the Kuchel Act provides in part as follows (16 U.S.C. § 695l):

"Notwithstanding any other provisions of law, all lands owned by the United States lying within the Executive order boundaries of the Tule Lake National Wildlife Refuge, the Lower Klamath National Wildlife Refuge, the Upper Klamath National Wildlife Refuge, and the Clear Lake Wildlife Refuge are hereby dedicated to wildlife conservation. Such lands shall be administered by the Secretary of the Interior for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith. Such lands shall not be opened to homestead entry. The following public lands shall also be included within the boundaries of the area dedicated to wildlife conservation, shall be administered by the Secretary of the Interior for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent therewith, and shall not be opened to homestead entry: Hanks Marsh, and first form withdrawal lands (approximately one thousand four hundred and forty acres) in Klamath County, Oregon, lying adjacent to Upper Klamath National Wildlife Refuge; White Lake in Klamath County, Oregon, and Siskiyou

County, California; and thirteen tracts of land in Siskiyou County, California, lettered as tracts 'A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I', 'J', 'K', 'L', and 'N' totaling approximately three thousand two hundred and ninety-two acres, and tract 'P' in Modoc County, California, containing about ten acres, all as shown on plate 4 of the report entitled 'Plan for Wildlife Use of Federal Lands in the Upper Klamath Basin, Oregon-California,' dated April 1956, prepared by the United States Fish and Wildlife Service. All the above lands shall remain permanently the property of the United States."

and

WHEREAS, in 1976, Congress enacted an amendment to the National Wildlife Refuge System Administration Act of 1966 (Pub. L. No. 94-223, 90 Stat. 199 (February 27, 1976)), hereinafter referred to as "the amendment"; and

WHEREAS, the amendment provides in part as follows:

"That subsection (a) of section 4 of the National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd(a)) is amended to read as follows:

(a)(1) For the purpose of consolidating the authorities relating to the various categories of areas that are administered by the Secretary of the Interior for the conservation of fish and wildlife, including species that are threatened with extinction, all lands, waters, and interests therein administered by the Secretary as wildlife refuges, areas for the protection and conservation of fish and wildlife that are threatened with extinction, wildlife ranges, game ranges, wildlife management areas, or waterfowl production areas are hereby designated as the 'National Wildlife Refuge System' (referred to herein as the 'System'), which shall be subject to the provisions of this section, and shall be administered by the Secretary through the United States Fish and Wildlife Service. ... "

and

WHEREAS, duly authorized representatives of the United States of America, Department of the Interior, have determined that under the amendment, all administrative control over the areas of land and water referred to in the Kuchel Act (hereinafter referred to as "the Kuchel Act lands") is vested in the Fish and Wildlife Service, as part of the National Wildlife Refuge System, but that the Service and the Bureau may enter into a Cooperative Agreement providing for the continued presence of and operations on the Kuchel Act lands by the Bureau, subject to the ultimate administrative control of the Service; and

WHEREAS, duly authorized representatives of the Service and the Bureau have determined that it is desirable to enter into such a Cooperative Agreement;

NOW, THEREFORE, it is hereby agreed by and between the parties hereto as follows:

1. The following general provisions shall apply to this Cooperative Agreement:

A. In accordance with the statutes cited above, under which the areas of land and water referred to in this Cooperative Agreement are part of the National Wildlife Refuge System and as such are to be administered through the Service, subject to the provisions of subparagraph B of this paragraph 1, such areas of land and water are under the administrative responsibility, control and direction of the Service, and any function or responsibility of the Bureau under this Cooperative Agreement is subject to such administrative responsibility, control and direction of the Service. The decision of the Service shall be binding with respect to any matter related to or arising out of the administration of such areas of land and water under the amendment; provided, however, that in the event of any dispute between the Service and the Bureau as to any such matter, the Service shall consult with the Bureau in an effort to resolve such dispute.

B. The following interests in water and project works held by the Bureau are within the geographical area covered by this Cooperative Agreement:

(1) Interests in water acquired and/or appropriated by the Bureau for reclamation purposes, including those referred to in the Klamath

River Basin Compact between the States of California and Oregon (approved, 71 Stat. 497).

(2) The following features within the boundaries of Tule Lake National Wildlife Refuge:

(a) N, P, Q, and R Canal and Lateral Systems

(b) No. 100, No. 101, and No. 102 Drain Systems

(c) Sumps 1A and 1B

(d) Pumping Plants 4; 5, 6, 9, 10, 11, C, D, W, X, and Y

(e) Inlet to Pumping Plant D and the Tule Lake Tunnel and bifurcation works

(f) All open and closed drains constructed by the Bureau

(g) All roads constructed within the Refuge by the Bureau

(h) A and B Dikes and any other dikes associated with the above-mentioned facilities

(i) Any other features that have been or will be constructed or approved by the Bureau for reclamation purposes.

(3) The following features within the boundaries of Lower Klamath National Wildlife Refuge:

(a) Klamath Straits Drain

(b) West, Center, and East Government Drains

(c) Range Line Drain

(d) State Line Drain in Oregon

(e) Pumping Plants E, EE, F, FF, and the O'Connor Pumping Plant

(f) P Canal System

(g) Long Drain

(h) O'Connor Drain

(i) Any other features that have been or will be constructed or approved by the Bureau for reclamation purposes.

(4) The following features within the boundaries of Clear Lake National Wildlife Refuge:

(a) Clear Lake Reservoir

(b) Clear Lake Dam and spillway

(c) Any other features that have been or will be constructed or approved by the Bureau for reclamation purposes.

The foregoing interests in water and project works relate solely to the reclamation function of the Bureau, and they do not relate in any way to the operation of the area as a part of the National Wildlife Refuge System by the Service. Therefore, such interest in water and project works are not within the administrative responsibility, control and direction of the Service referred to in subparagraph A of this paragraph 1.

C. Subject to the provisions of subparagraph B of this paragraph 1, and any specific provision of this Cooperative Agreement, with respect to any provision of this Cooperative Agreement under which a management function is granted to and assumed by the Bureau, such management function shall be as follows:

(1) The Bureau will conduct leasing programs in the following manner:

(a) The Bureau will prepare the leasing programs for a defined period of time in sufficient detail to ensure that prospective lessees will be able to raise listed grains and row crops subject to limitations on the use of chemicals, burning of stubble, methods of cultivation, irrigation, harvesting, and any other appropriate limitations as may be necessary. The Bureau shall consult with and obtain the approval of the Service in developing the agricultural leasing program.

(b) The Bureau will write all lease advertisements and submit them to the Service for a two-week review period. After such review period and after the Bureau and the Service have mutually agreed on the form and content of the lease agreements, the Bureau will publicly issue the lease advertisements. The advertisements, or any repeated advertisements issued due to nonrenewal of a lease, shall not thereafter be changed.

The various sections of leased lands in the area covered by this Cooperative Agreement shall be leased on a staggered basis, so that all leases for the entire year are not awarded in any single year.

(c) The Bureau shall specify the time, place, and conduct of the bid openings for leases and shall invite Service representatives to observe the bid opening proceedings.

(d) The Bureau shall review the eligibility of each bidder to hold a lease and shall accept or reject bidders on the basis of said review.

(e) The Bureau shall conduct all interviews regarding the proposed use of the lease and the Statement of Operations.

(f) The Bureau shall execute all lease contracts in accordance with the terms of the lease advertisements and the terms of this agreement. No changes in the lease contracts shall be made during the term of the lease including permitted renewal periods.

(g) The Bureau shall conduct all compliance reviews of the lease contracts and enforcement of the leasing requirements as they relate to: crop rotation; seed certification; water use; drainage; pesticide, rodenticide, and herbicide uses; row crop acreages in conformance with the Kuchel Act; land management practices; and any other terms or conditions stipulated in the lease advertisements or contracts.

(2) The Bureau shall practice soil moisture conservation in the following manner:

(a) Seeding of canal and lateral berms to prevent soil erosion and to develop wildlife habitat.

(b) Supervision of and advice to lessees on annual and noxious weed control on agricultural lease lands and irrigation drainage facilities.

(c) Conduct of quackgrass control measures to assure optimum agricultural production on leased lands.

(3) The Bureau shall conduct salt balance studies on all agricultural lease lands in order to prevent drainage or soil problems from developing and to maintain optimum agricultural production. The studies shall consist of periodic collection and analysis of water samples from key areas to determine water quality and control measures and collection and analysis of soil samples after each irrigation season to determine salt content and/or alkaline conditions.

(4) The Bureau shall prepare and compile in-lieu-of-tax data for payments to counties as required under the Kuchel Act including documents for completion of payments.

(5) The Bureau shall prepare any other reports as necessary.

2. Subject to the provisions of paragraph 1 of this Cooperative Agreement, the functions and responsibilities of the Service and the Bureau with respect to the areas of the National Wildlife Refuge System in Modoc and Siskiyou Counties, California, and Klamath County, Oregon, shall be as follows:

A. Lands within the boundary of the Tule Lake National Wildlife Refuge as described in Executive Orders dated October 4, 1928, November 3, 1932, and April 10, 1936, and in the Act of March 23, 1933, Priv. L. No. 2, 73d Cong., and the Act of June 14, 1933, Priv. L. No. 12, 73d Cong., 48 Stat. 1295 and 1300, excepting those presently under private ownership.

(1) The area so described is shown on the attached Exhibit A and consists of:

(a) Reclaimed lakebed lands of the State of California ceded by Legislative Act of 1905 and accepted by Act of Congress dated February 9, 1905 (33 Stat. 714) (hereinafter called Tule Lake ceded lands).

(b) Lakebed lands not reclaimed by drainage and used as the operating sump for accumulation of flood, waste and return flow waters of the Klamath Project, as authorized by the California Legislative Act of 1905 (hereinafter called the Sump).

(c) Native uplands.

(2) The functions and responsibilities of each bureau regarding the lands within the Tule Lake National Wildlife Refuge shall be as follows, subject to the provisions of paragraph 1 of this agreement:

(a) The Tule Lake ceded lands shall be managed by the Bureau, provided that leasing or use of that portion of the Tule Lake ceded lands adjacent to the Sump (hereinafter referred to as buffer zones), shall be in accordance with Article 8 of the Contract No. 14-06-200-5954 dated September 10, 1956, between the United States and the Tulelake Irrigation District. It is understood that such buffer zones hereafter shall be used by the Service for the growing of wildlife habitat either directl or by lease or sharecrop arrangements, but if revenues are obtained therefrom, they shall be transferred to the Bureau in accordance with the Kuchel Act. Leasing of the remaining Tule Lake ceded lands shall be continued by the Bureau pursuant to in accordance with the provisions of the Kuchel Act. Each leas shall contain reservations for public hunting, fishing, and other recreational uses at such times and places which as deter mined by the Service after consultation with the Bureau do not materially interfere with the lessee's land preparation, seedir growing, irrigating and primary harvesting of the crops thereon Fall burning or plowing of grain stubble or crop residues shall not be permitted on more than 10% of the leased lands except by express permission of the Service. Terms and conditions relating to spring burning shall be subject to the approval of the Service. Administration of all laws and regulations relating to wildlife on the Tule Lake ceded lands, and all use of the ceded lands for trapping and for hunting, fishing, and other recreational uses shall be by and through the Service and the proceeds received therefrom shall be retained by the Service in accordance with 16 U.S.C. § 715s.

(b) Those facilities described in Article 7 of Contract No. 14-06-200-5954, dated September 10, 1956, shall be retained under the administrative authority of the Bureau as project works. Administration of wildlife matters, and enforcement of all laws and regulations relating to wildlife on such areas, and all use of such areas for hunting, fishing, trapping, boating, recreational and other Refuge uses shall be by and through the Service. The proceeds received therefrom shall be retained by the Service in accordance with 16 U.S.C. § 715s.

(c) Administration of the native uplands area shall be by the Service, subject to reasonable use of the area by the Bureau for borrow material with full consideration to environmental concerns.

B. Lands within the boundary of the Lower Klamath National Wildlife Refuge as described in the Executive Orders dated August 8, 1908, and May 14, 1915 excepting those presently under private ownership.

(1) The area so described is shown on the attached Exhibit B and consists of:

(a) The Klamath Straits Unit in Klamath County, Oregon.

(b) The area in California developed for Refuge purposes under the 1942 Agreement between the Bureau and the Service, hereinafter designated as the "Intensive Use Area."

(c) Lands owned by the United States not presently developed for Refuge purposes, exclusive of the Klamath Straits Unit, consisting of:

1. Miller Lake Area, Oregon and California.

2. Sheepy West.

3. Sheepy East.

(d) Ady Canal (also known as the South Canal).

(e) Klamath Straits Drain.

(2) The functions and responsibilities of each bureau regarding the lands within the Lower Klamath National Wildlife Refuge shall be as follows, subject to the provisions of paragraph 1 of this agreement:

(a) The Klamath Straits Unit shall be managed by the Bureau. Leasing of the Klamath Straits Unit shall be by the Bureau pursuant to and in accordance with the provisions of the Kuchel Act. Each lease shall contain reservations for public hunting, fishing, and other recreational uses at such times and places which as determined by the Service after consultation with the Bureau do not materially interfere with the lessee's land prepara-tion, seeding, growing, irrigation, and primary harvesting of the crops thereon. Fall burning or plowing of grain stubble or crop residues shall not be permitted on more than 10% of the leased area except by express permission of the Service. Terms and conditions relating to spring burning shall be subject to the approval of the Service. Administration of all laws and regula-tions relating to wildlife on the Klamath Straits Unit, and all use of these lands for trapping and for hunting, fishing, and other recreational uses shall be by and through the Service, and the proceeds received therefrom shall be retained by the Service in accordance with 16 U.S.C. § 715s.

(b) The Intensive Use Area in California shall be administered by and through the Service for all purposes, subject to the continued discharge of Sump water through the existing Pumping Plant D, Tunnel, P Canal System, and private lands watered from the P Canal System of the Klamath Project, into the Intensive Use Area or such by-pass canal facilities as the Service or Bureau may provide to carry such Sump water directly to the Klamath Straits Drain; provided, however, that the Bureau shall provide in its water service contracts for privately owned or leased public lands served by the P Canal System that impounded waters on such lands shall not be released therefrom except at times when the Service determines that there is capacity in the Refuge or drains to handle such released waters. The Bureau, pursuant to existing or future contracts, shall remove excess waters from the Intensive Use Area and other areas in California described in the Kuchel Act and located in Lower Klamath Lake area. Excess waters shall be defined as those that are greater than the capacity of areas to hold and use without adversely affecting wildlife requirements therein as determined annually by the Service. Any revenues derived from hunting, fishing, trapping, or grazing or other use of the Intensive Use Area shall be retained by the Service in accordance with 16 U.S.C. § 715s.

(c) Lands owned by the United States not presently developed for refuge purposes as described in subparagraph B(1)(c) above, except Sheepy East, shall be administered by the Service in accordance with the Kuchel Act, and the proceeds shall be retaine by the Service in accordance with 16 U.S.C. § 715s. Administration of all laws and regulations relating to wildlife on these lands, and all use of these lands for trapping and for hunting, fishing, and other recreational uses shall be by and through the Service, and the proceeds received therefrom shall be retained by the Service in accordance with 16 U.S.C. § 715s.

(d) The Sheepy East Unit shall be managed by the Bureau for agricultural purposes. Leasing of these lands shall be by the Bureau for agricultural purposes, pursuant to and in accordance with the Kuchel Act. Each lease shall contain reservations for public hunting, fishing, and other recreational uses, at such times and places which as determined by the Service after consultation with the Bureau do not materially interfere with the lessee's land preparation, seeding, growing, irrigating, and primary harvesting of crops thereon. Fall burning or plowing of grain stubble or crop residues shall not be permitted on more than 10% of the leased area except by express permission of the Service. Terms and conditions relating to spring burning shall be subject to the approval of the Service. Administration of all laws and regulations relating to wildlife on these lands, and all use of these lands for trapping and for hunting, fishing, and other recreational uses shall be by and through the Service, and the proceeds received therefrom shall be retained by the Service in accordance with 16 U.S.C. § 715s.

(e) The interest of the United States in the Ady Canal, also known as the South Canal, is a contractual right pursuant to Amendatory Contract Ilr-402, dated April 28, 1943, between the United States and the Klamath Drainage District. This contract and all of its terms and conditions shall be administered by the Service.

(f) The Klamath Straits Drain shall be retained under the administrative authority of the Bureau, and it shall be operated and maintained by the Bureau subject to the terms and conditions of Supplemental Contract No. Ilr-402, dated October 11, 1947, between the United States and the Klamath Drainage District and any future contracts relating thereto.

C. Lands within the boundary of the Upper Klamath National Wildlife Refuge as described in Executive Order dated April 3, 1928, the First Form Withdrawal lands, also known as Northern Extension Tract, and lands acquired by the Service adjacent thereto, and Hanks Marsh.

(1) The area so described is shown on the attached Exhibit C and consists of:

(a) Executive Order described lands and accretions thereto.

(b) Lands acquired by the Service.

(c) First Form Withdrawal lands (1440 acres), also known as Northern Extension Tract.

(d) Hanks Marsh.

(2) The Service shall administer these lands subject to raising an lowering of the water levels of Upper Klamath Lake for Klamath Proj purposes. The lands so administered by and through the Service wil be affected by fluctuations of water levels in the Upper Klamath La which is utilized for water-storage purposes by the Klamath Project and by Pacific Power and Light Company pursuant to Contract No. 14-06-200-5075, dated January 31, 1956, between its predecessor, California-Oregon Power Company, and the United States. Administra of all laws and regulations relating to wildlife on these lands, an all use of these lands for grazing and for trapping and hunting, fishing, and other recreational uses shall be by and through the Service, and the proceeds received therefrom shall be retained by th Service in accordance with 16 U.S.C. § 715s.

D. Lands within the boundary of Clear Lake National Wildlife Refuge as described in Executive Order dated April 11, 1911, and the amendment date January 13, 1912:

(1) The area so described is shown on the attached Exhibit D and includes all lands owned by the United States lying within the Executive Order boundary.

(2). The Clear Lake National Wildlife Refuge shall be administered b the Service, and the proceeds received therefrom shall be retained b the Service in accordance with 16 U.S.C. § 715s. Leasing in this ar for grazing shall be by the Service in accordance with the provision of the Kuchel Act, and proceeds received therefrom shall be retained by the Service in accordance with 16 U.S.C. § 715s. All use of these lands for trapping and for hunting, fishing and other recreational uses shall be by and through the Service, and the proceeds therefrom shall be retained by the Service in accordance with 16 U.S.C. § 715s

E. White Lake, and Lettered Tracts in the Lower Klamath Area:

(1) The area so described is shown on the attached Exhibit A and consists of:

(a) White Lake in Klamath County, Oregon, and Siskiyou County, California.

(b) Thirteen tracts of land in Siskiyou County, lettered as Tracts "A", "B", "C", "D", "E", "F", "G", "H", "I", "J", "K", "L", and "N".

(c) Tract "P" in Modoc County.

(2) The administrative responsibility for these lands shall be by and through the Service, and the proceeds received therefrom shall be retained by the Service in accordance with 16 U.S.C. § 715s.

3. This Cooperative Agreement shall control in the case of any conflict between the terms hereof and the terms of the January 8, 1942, Agreement and the June 28, 1946, amendment.

4. Any management function of the Bureau hereunder which is subject to the administrative responsibility and control of the Service, or all such management functions, may be terminated at any time by either party giving written notice to the other party at least one (1) year in advance of the date of such termination. This Cooperative Agreement may be terminated at any time, subject to the approval of the Secretary, by either party giving written notice to

the other party at least one (1) year in advance of the proposed date of such termination.

By ____________________
Commissioner, Bureau of Reclamation

By Lynn A. Greenwalt
Director, Fish and Wildlife Service
Lynn A. Greenwalt

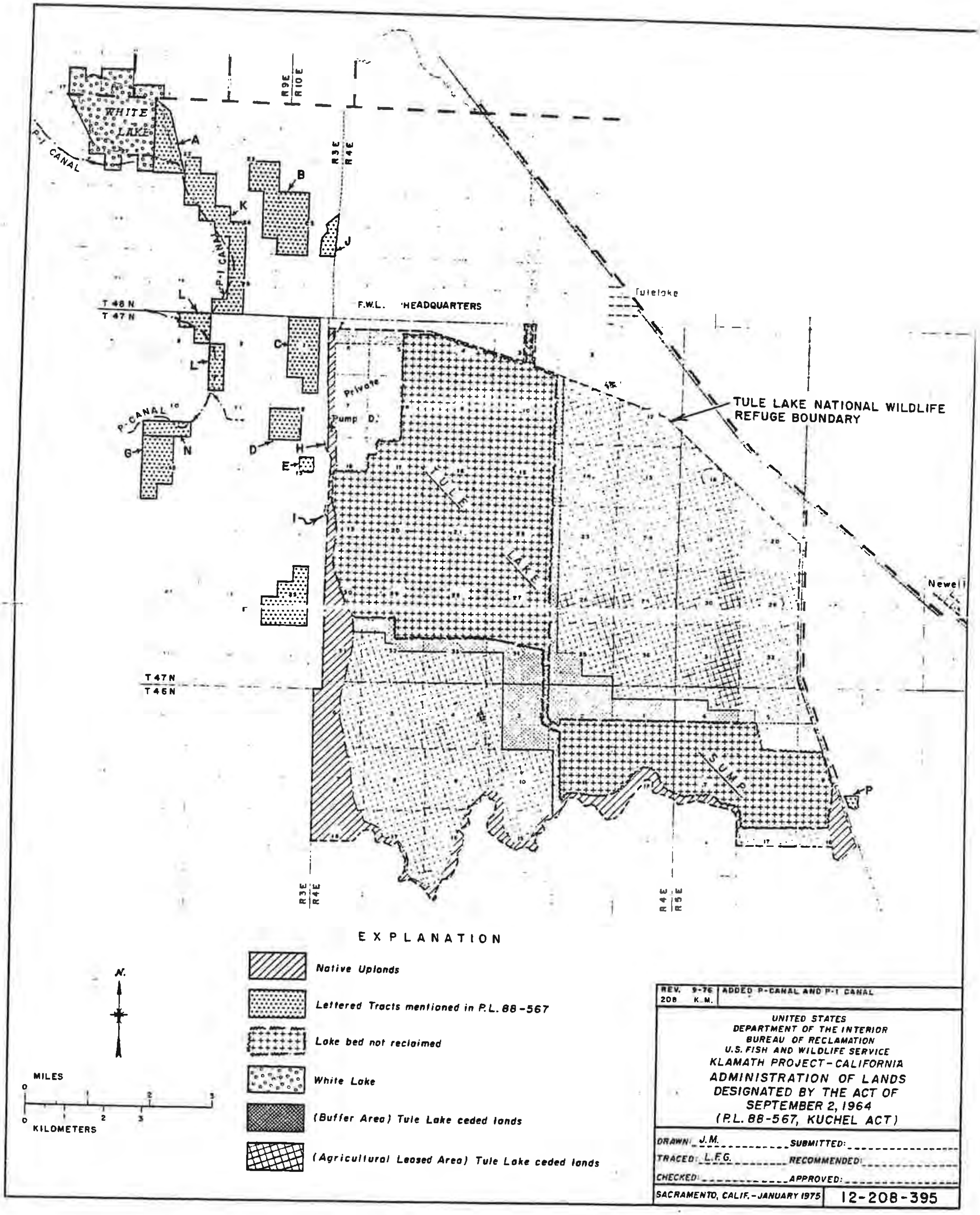

WHITE LAKE
P-1 CANAL
A
B
K
J
P-1 CANAL
L
T 48 N
T 47 N
F.W.L. HEADQUARTERS
Tulelake
R9E
R10E
R3E
R4E
C
L
Private
Pump D.
P-CANAL
G
N
D
H
E
I
TULE LAKE NATIONAL WILDLIFE REFUGE BOUNDARY
TULE LAKE
Newell
T47N
T46N
SUMP
P
R3E
R4E
R4E
R5E
EXPLANATION
Native Uplands
Lettered Tracts mentioned in P.L. 88-567
Lake bed not reclaimed
White Lake
(Buffer Area) Tule Lake ceded lands
(Agricultural Leased Area) Tule Lake ceded lands
N.
MILES
0
1
2
3
0
1
2
3
KILOMETERS
REV. 9-76
208 K.M.
ADDED P-CANAL AND P-1 CANAL
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
U.S. FISH AND WILDLIFE SERVICE
KLAMATH PROJECT-CALIFORNIA
ADMINISTRATION OF LANDS
DESIGNATED BY THE ACT OF
SEPTEMBER 2, 1964
(P.L. 88-567, KUCHEL ACT)
DRAWN: J.M.
SUBMITTED:
TRACED: L.F.G.
RECOMMENDED:
CHECKED:
APPROVED:
SACRAMENTO, CALIF.-JANUARY 1975
12-208-395

EXHIBIT A

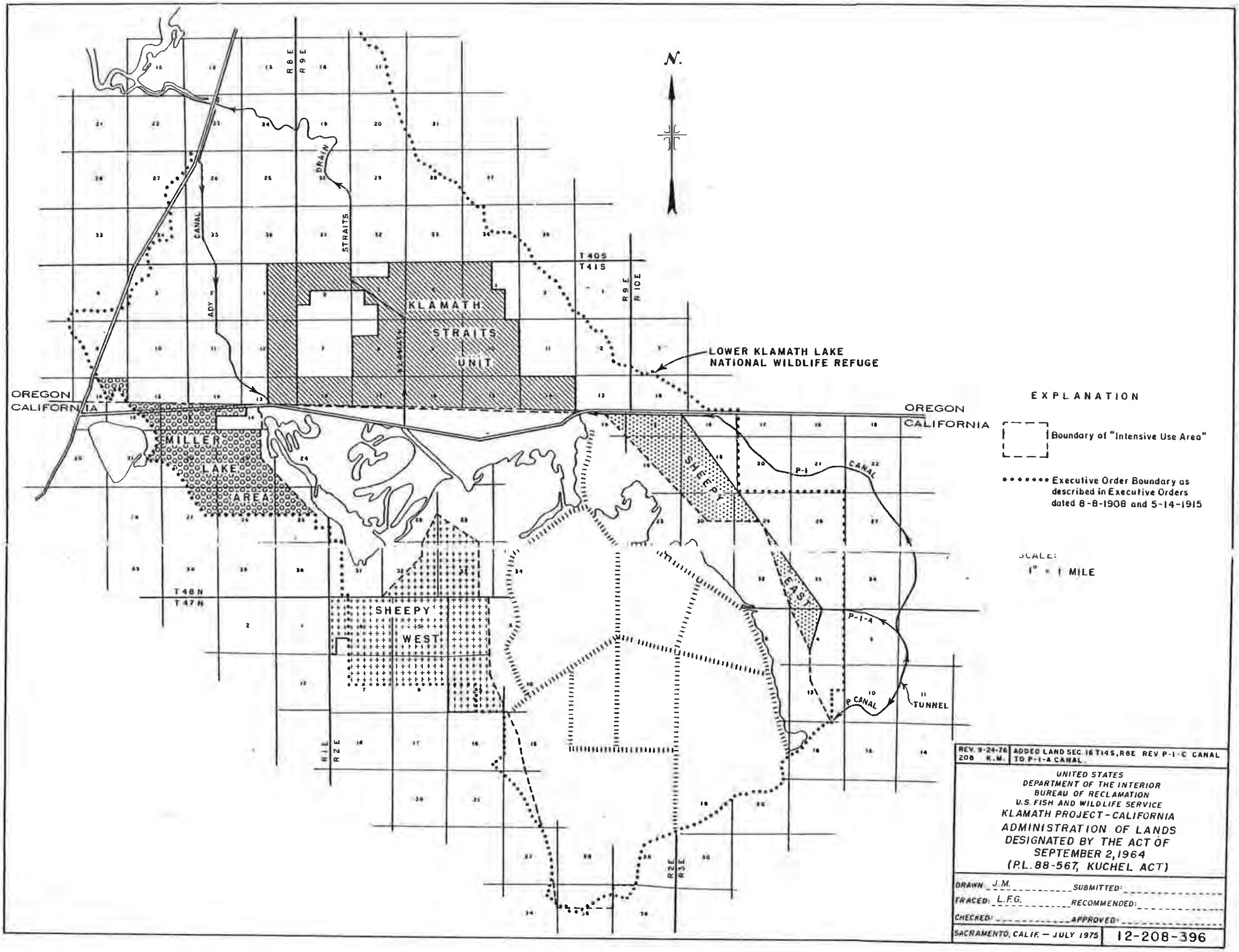
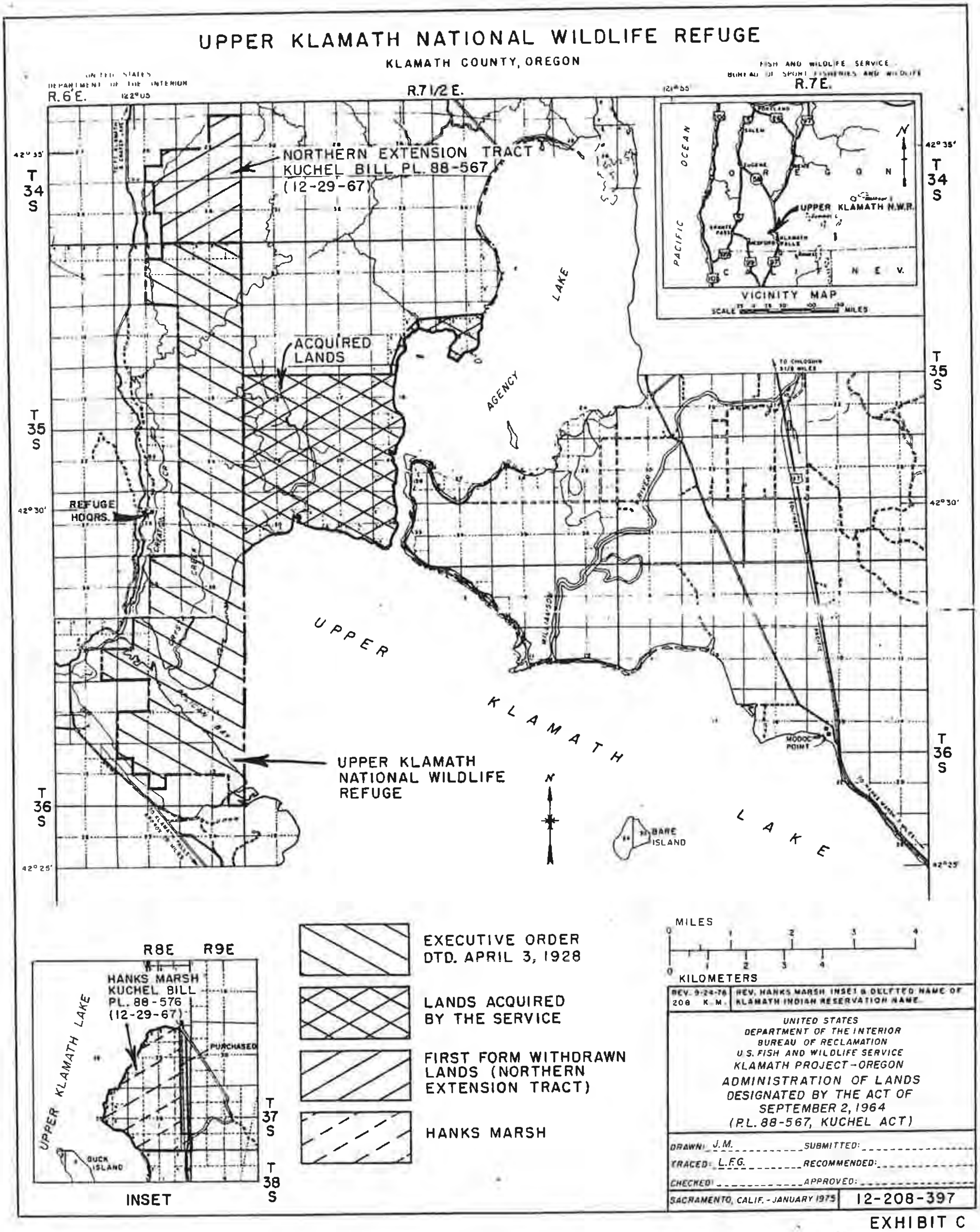
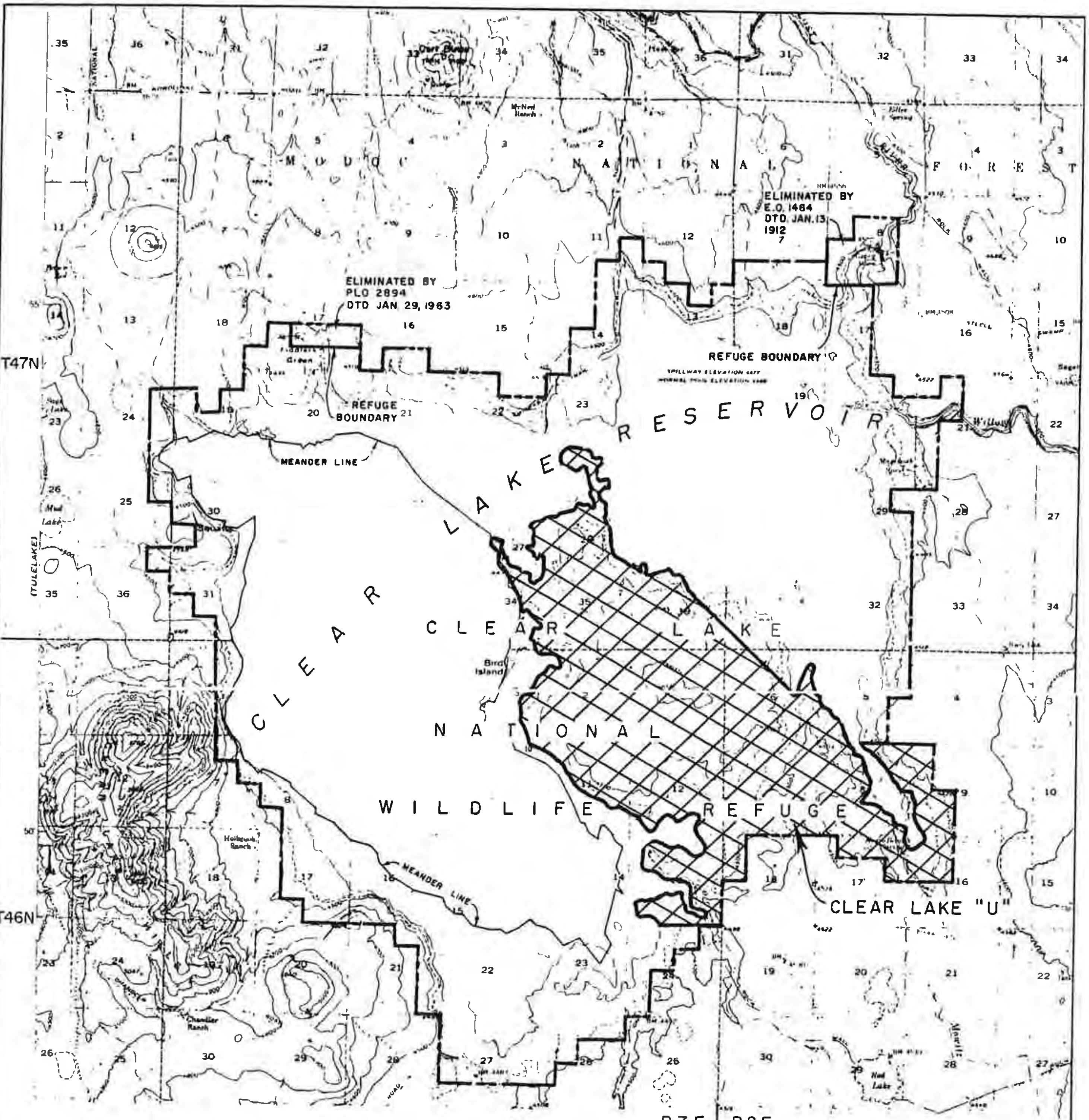

N.
LOWER KLAMATH LAKE
NATIONAL WILDLIFE REFUGE
KLAMATH STRAITS UNIT
MILLER LAKE AREA
SHEEPY WEST
SHEEPY EAST
OREGON
CALIFORNIA
STRAITS DRAIN
ADY CANAL
P-1 CANAL
P-1-A
P CANAL
TUNNEL
T40S
T41S
T48N
T47N
R8E
R9E
R10E
R1E
R2E
R3E
EXPLANATION
Boundary of "Intensive Use Area"
Executive Order Boundary as described in Executive Orders dated 8-8-1908 and 5-14-1915
SCALE:
1" = 1 MILE
REV. 9-24-76 208 K.M. ADDED LAND SEC. 16 T41S, R8E REV P-1-C CANAL TO P-1-A CANAL.
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
U.S. FISH AND WILDLIFE SERVICE
KLAMATH PROJECT - CALIFORNIA
ADMINISTRATION OF LANDS
DESIGNATED BY THE ACT OF
SEPTEMBER 2, 1964
(P.L. 88-567, KUCHEL ACT)
DRAWN: J.M. SUBMITTED:
TRACED: L.F.G. RECOMMENDED:
CHECKED: APPROVED:
SACRAMENTO, CALIF. — JULY 1975
12-208-396

EXHIBIT B



UPPER KLAMATH NATIONAL WILDLIFE REFUGE
KLAMATH COUNTY, OREGON
UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
R.6 E.
R.7 1/2 E.
R.7 E.
NORTHERN EXTENSION TRACT
KUCHEL BILL PL. 88-567
(12-29-67)
ACQUIRED LANDS
REFUGE HDQRS.
UPPER KLAMATH LAKE
AGENCY LAKE
UPPER KLAMATH NATIONAL WILDLIFE REFUGE
MODOC POINT
BARE ISLAND
VICINITY MAP
UPPER KLAMATH N.W.R.
PACIFIC OCEAN
OREGON
CALIF.
NEV.
T 34 S
T 35 S
T 36 S
42°35'
42°30'
42°25'
MILES
KILOMETERS
R8E R9E
HANKS MARSH
KUCHEL BILL
PL. 88-576
(12-29-67)
PURCHASED
DUCK ISLAND
T 37 S
T 38 S
INSET
EXECUTIVE ORDER DTD. APRIL 3, 1928
LANDS ACQUIRED BY THE SERVICE
FIRST FORM WITHDRAWN LANDS (NORTHERN EXTENSION TRACT)
HANKS MARSH
REV. 9-24-76 208 K.M. REV. HANKS MARSH INSET & DELETED NAME OF KLAMATH INDIAN RESERVATION NAME.
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
U.S. FISH AND WILDLIFE SERVICE
KLAMATH PROJECT-OREGON
ADMINISTRATION OF LANDS DESIGNATED BY THE ACT OF SEPTEMBER 2, 1964
(P.L. 88-567, KUCHEL ACT)
DRAWN: J.M. SUBMITTED:
TRACED: L.F.G. RECOMMENDED:
CHECKED: APPROVED:
SACRAMENTO, CALIF. - JANUARY 1975
12-208-397

EXHIBIT C



EXECUTIVE ORDER 1332
DTD. APRIL 11, 1911

CLEAR LAKE "U"
LEASE AREA

FEET
0 2 4 6 8 10,000
0 2 4 6 8 10,000
METERS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
U.S. FISH AND WILDLIFE SERVICE
KLAMATH PROJECT-CALIFORNIA
ADMINISTRATION OF LANDS
DESIGNATED BY THE ACT OF
SEPTEMBER 2, 1964
(P.L. 88-567, KUCHEL ACT)

DRAWN: J.M. SUBMITTED:
TRACED: L.F.G. RECOMMENDED:
CHECKED: APPROVED:

REV. 208	9-76 K.M.	REMOVED HATCHING ADDED BDRY. SYMBOL IN EXPLANATION.

SACRAMENTO, CALIF.-JANUARY 1975 | 12-208-398

EXHIBIT D

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Appendix S – Endangered Species Act Compliance

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[This appendix will be provided in the public Final CCP/EIS.]

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Appendix T – Tule Lake Proclamation

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Federal Register

Wednesday,

December 10, 2008

Part IV

The President

Proclamation 8327—Establishment of the World War II Valor In the Pacific National Monument

Federal Register
Vol. 73, No. 238
Wednesday, December 10, 2008

Presidential Documents

Title 3—

The President

Proclamation 8327 of December 5, 2008

Establishment of the World War II Valor In the Pacific National Monument

By the President of the United States of America

A Proclamation

Beginning at Pearl Harbor with the day of infamy that saw the sinking of the USS ARIZONA and ending on the deck of the USS MISSOURI in Tokyo Bay, many of the key battles of World War II were waged on and near American shores and throughout the Pacific. We must always remember the debt we owe to the members of the Greatest Generation for our liberty. Their gift is an enduring peace that transformed enemies into steadfast allies in the cause of democracy and freedom around the globe.

Americans will never forget the harrowing sacrifices made in the Pacific by soldiers and civilians that began at dawn on December 7, 1941, at Pearl Harbor on the island of Oahu. The surprise attack killed more than 2,000 American military personnel and dozens of civilians and thrust the United States fully into World War II.

America responded and mobilized our forces to fight side-by-side with our allies in the European, Atlantic, and Pacific theaters. The United States Navy engaged in epic sea battles, such as Midway, and our Armed Forces fought extraordinary land battles for the possession of occupied islands. These battles led to significant loss of life for both sides, as well as for the island's native peoples. Battlegrounds such as Guadalcanal, Tarawa, Saipan, Guam, Peleliu, the Philippines, Iwo Jima, and Okinawa are remembered for the heroic sacrifices and valor displayed there.

The conflict raged as far north as the Alaskan territory. The United States ultimately won the encounter in the Aleutian Island chain but not without protracted and costly battles.

There were also sacrifices on the home front. Tens of millions of Americans rallied to support the war effort, often at great personal cost. Men and women of all backgrounds were called upon as industrial workers, volunteers, and civil servants. Many Americans valiantly supported the war effort even as they struggled for their own civil rights.

In commemoration of this pivotal period in our Nation's history, the World War II Valor in the Pacific National Monument adds nine historic sites to our national heritage of monuments and memorials representing various aspects of the war in the Pacific.

Five of those sites are in the Pearl Harbor area, which is the home of both the USS ARIZONA and the USS MISSOURI—milestones of the Pacific campaign that mark the beginning and the end of the war. The sites in this area include: the USS ARIZONA Memorial and Visitor Center, the USS UTAH Memorial, the USS OKLAHOMA Memorial, the six Chief Petty Officer Bungalows on Ford Island, and mooring quays F6, F7, and F8, which constituted part of Battleship Row. The USS ARIZONA and USS UTAH vessels will not be designated as part of the national monument, but instead will be retained by the Department of Defense (through the Department of the Navy) as the final resting place for those entombed there.

Three sites are located in Alaska's Aleutian Islands. The first is the crash site of a Consolidated B-24D Liberator bomber—an aircraft of a type that played a highly significant role in World War II—located on Atka Island. The second is the site of Imperial Japan's occupation of Kiska Island, beginning in June 1942, which marks the northern limit of Imperial Japan's expansion in the Pacific. The Kiska site includes historic relics such as Imperial Japanese coastal and antiaircraft defenses, camps, roads, an airfield, a submarine base, a seaplane base, and other installations, as well as the remains of Allied defenses, including runway facilities and gun batteries.

The third Aleutian designation is on Attu Island, the site of the only land battle fought in North America during World War II. It still retains the scars of the battle: thousands of shell and bomb craters in the tundra; Japanese trenches, foxholes, and gun encampments; American ammunition magazines and dumps; and spent cartridges, shrapnel, and shells located at the scenes of heavy fighting. Attu later served as a base for bombing missions against Japanese holdings.

The last of the nine designations will bring increased understanding of the high price paid by some Americans on the home front. The Tule Lake Segregation Center National Historic Landmark and nearby Camp Tule Lake in California were both used to house Japanese-Americans relocated from the west coast of the United States. They encompass the original segregation center's stockade, the War Relocation Authority Motor Pool, the Post Engineer's Yard and Motor Pool, a small part of the Military Police Compound, several historic structures used by internees and prisoners of war at Camp Tule Lake, and the sprawling landscape that forms the historic setting.

WHEREAS much of the Federal property within the World War II Valor in the Pacific National Monument is easily accessible to visitors from around the world;

WHEREAS the Secretary of the Interior should be authorized and directed to interpret the broader story of World War II in the Pacific in partnership with the Department of Defense, the States of Hawaii, Alaska, and California, and other governmental and non-profit organizations;

WHEREAS the World War II Valor in the Pacific National Monument will promote understanding of related resources, encourage continuing research, present interpretive opportunities and programs for visitors to better understand and honor the sacrifices borne by the Greatest Generation, and tell the story from Pearl Harbor to Peace;

WHEREAS section 2 of the Act of June 8, 1906 (34 Stat. 225, 16 U.S.C. 431) (the ''Antiquities Act'') authorizes the President, in his discretion, to declare by public proclamation historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest that are situated upon lands owned or controlled by the Government of the United States to be national monuments, and to reserve as a part thereof parcels of land, the limits of which in all cases shall be confined to the smallest area compatible with the proper care and management of the objects to be protected;

WHEREAS it is in the public interest to preserve the areas described above and on the attached maps as the World War II Valor in the Pacific National Monument;

NOW, THEREFORE, I, GEORGE W. BUSH, President of the United States of America, by the authority vested in me by section 2 of the Act of June 8, 1906 (34 Stat. 225, 16 U.S.C. 431), do proclaim that there are hereby set apart and reserved as the World War II Valor in the Pacific National Monument for the purpose of protecting the objects described above, all lands and interests in lands owned or controlled by the Government of the United States within the boundaries described on the accompanying maps, which are attached and form a part of this proclamation. The Federal lands and interests in land reserved consist of approximately 6,310 acres, which is the smallest area compatible with the proper care and management of the objects to be protected.

All Federal lands and interests in lands within the boundaries of this monument are hereby appropriated and withdrawn from all forms of entry, location, selection, sale, leasing, or other disposition under the public land laws, including, but not limited to, withdrawal from location, entry, and patent under mining laws, and from disposition under all laws relating to mineral and geothermal leasing.

Management of the National Monument

The Secretary of the Interior shall manage the monument through the National Park Service and the U.S. Fish and Wildlife Service, pursuant to applicable legal authorities, to implement the purposes of this proclamation. The National Park Service shall generally administer the national monument, except that the U.S. Fish and Wildlife Service shall administer the portions of the national monument that are within a national wildlife refuge. The National Park Service and the U.S. Fish and Wildlife Service may prepare an agreement to share, consistent with applicable laws, whatever resources are necessary to properly manage the monument.

For the purposes of preserving, interpreting, and enhancing public understanding and appreciation of the national monument and the broader story of World War II in the Pacific, the Secretary of the Interior, in consultation with the Secretary of Defense, shall prepare a management plan within 3 years of the date of this proclamation.

The Secretary of the Interior shall have management responsibility for the monument sites and facilities in Hawaii within the boundaries designated on the accompanying maps to the extent necessary to implement this proclamation, including the responsibility to maintain and repair the Chief Petty Officer Bungalows and other monument facilities. The Department of Defense may retain the authority to control access to those sites. The Department of the Interior through the National Park Service and the Department of the Navy may execute an agreement to provide for the operational needs and responsibilities of each Department in implementing this proclamation.

Armed Forces Actions

1. The prohibitions required by this proclamation shall not restrict activities and exercises of the Armed Forces (including those carried out by the United States Coast Guard).

2. All activities and exercises of the Armed Forces shall be carried out in a manner that avoids, to the extent practicable and consistent with operational requirements, adverse impacts on monument resources and qualities.

3. In the event of threatened or actual destruction of, loss of, or injury to a monument resource or quality resulting from an incident, including but not limited to spills and groundings, caused by a component of the Department of Defense or any other Federal agency, the cognizant component shall promptly coordinate with the Secretary of the Interior for the purpose of taking appropriate actions to respond to and mitigate the harm and, if possible, restore or replace the monument resource or quality.

4. Nothing in this proclamation or any regulation implementing it shall limit or otherwise affect the Armed Forces' discretion to use, maintain, improve, or manage any real property under the administrative control of a Military Department or otherwise limit the availability of such real property for military mission purposes.

The establishment of this monument is subject to valid existing rights.

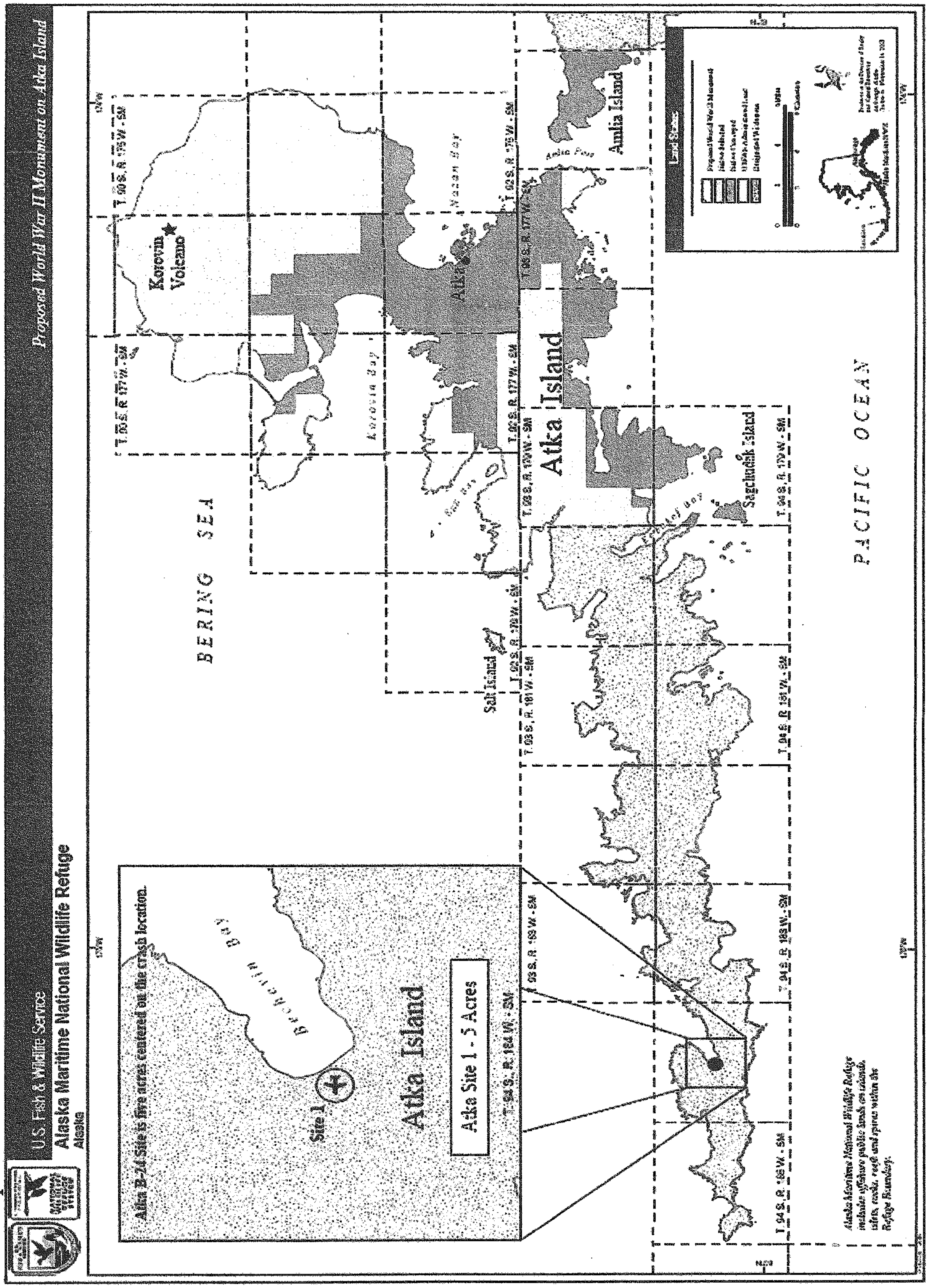
Nothing in this proclamation shall be deemed to revoke any existing withdrawal, reservation, or appropriation; however, the national monument shall be the dominant reservation.

Nothing in this proclamation shall alter the authority of any Federal agency to take action in the monument area where otherwise authorized under applicable legal authorities, except as provided by this proclamation.

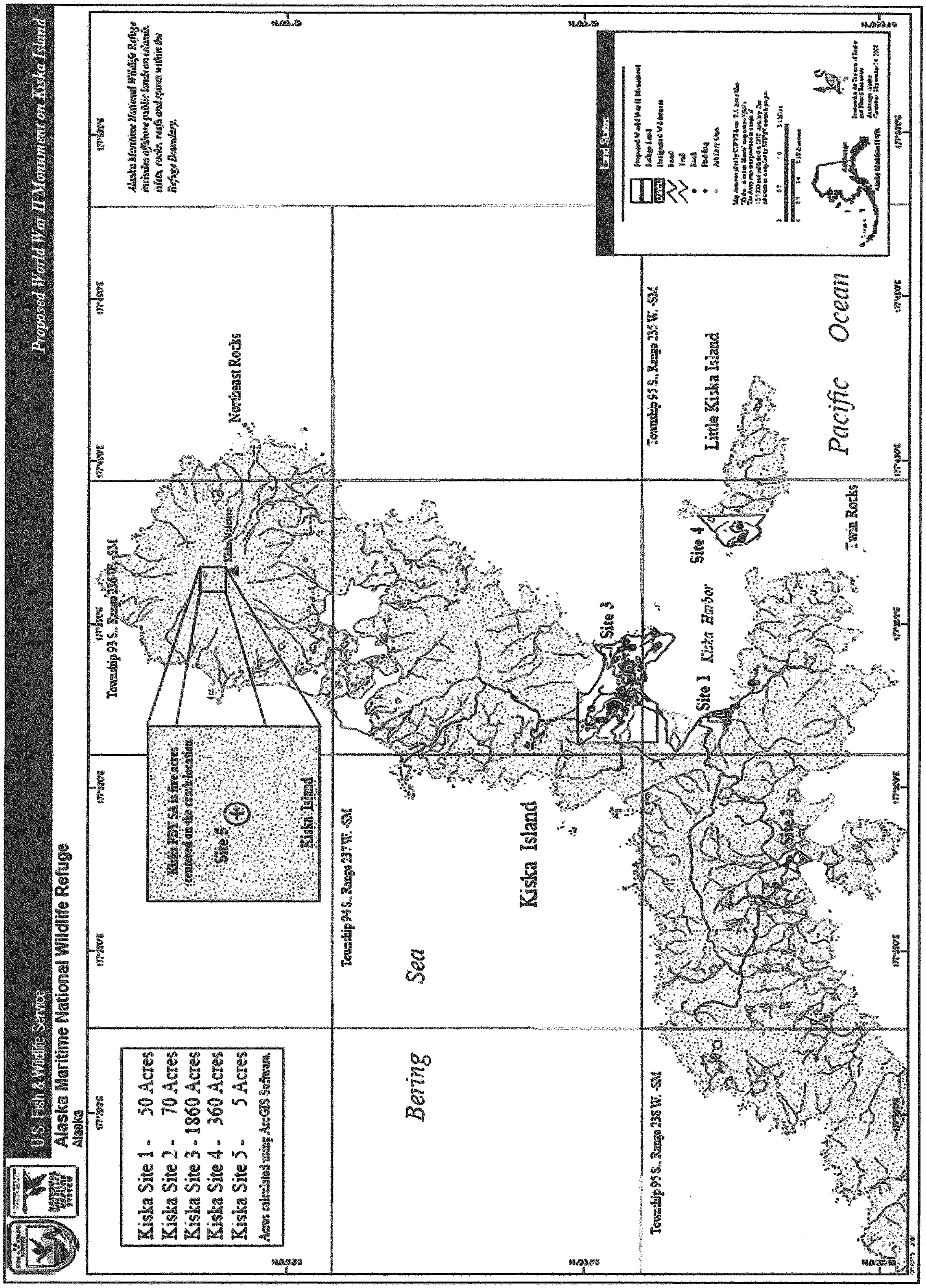
Warning is hereby given to all unauthorized persons not to appropriate, injure, destroy, or remove any feature of this monument and not to locate or settle upon any lands thereof.

IN WITNESS WHEREOF, I have hereunto set my hand this fifth day of December, in the year of our Lord two thousand eight, and of the Independence of the United States of America the two hundred and thirty-third.

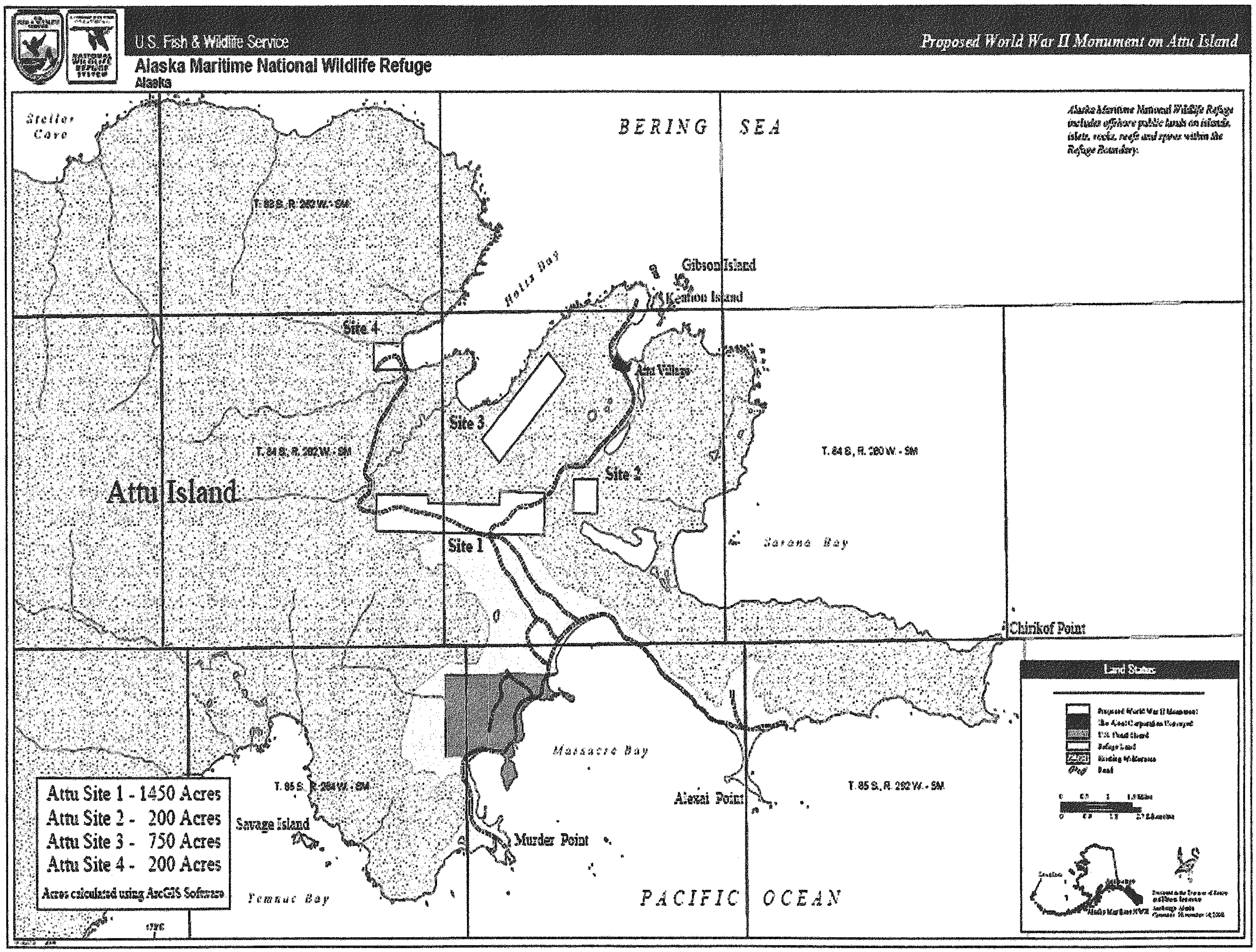
Map A – Atka Island



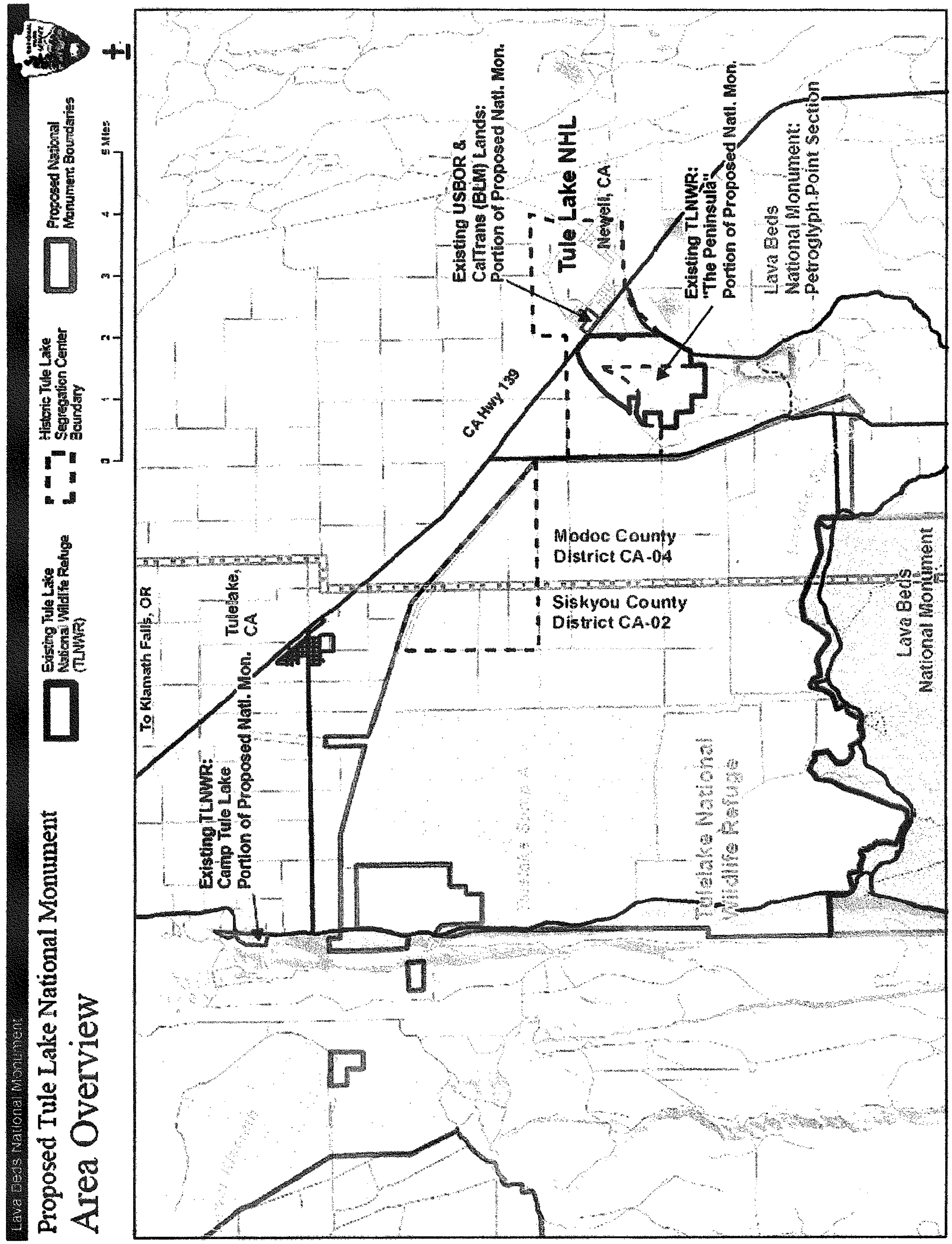
Map B – Kiska Island



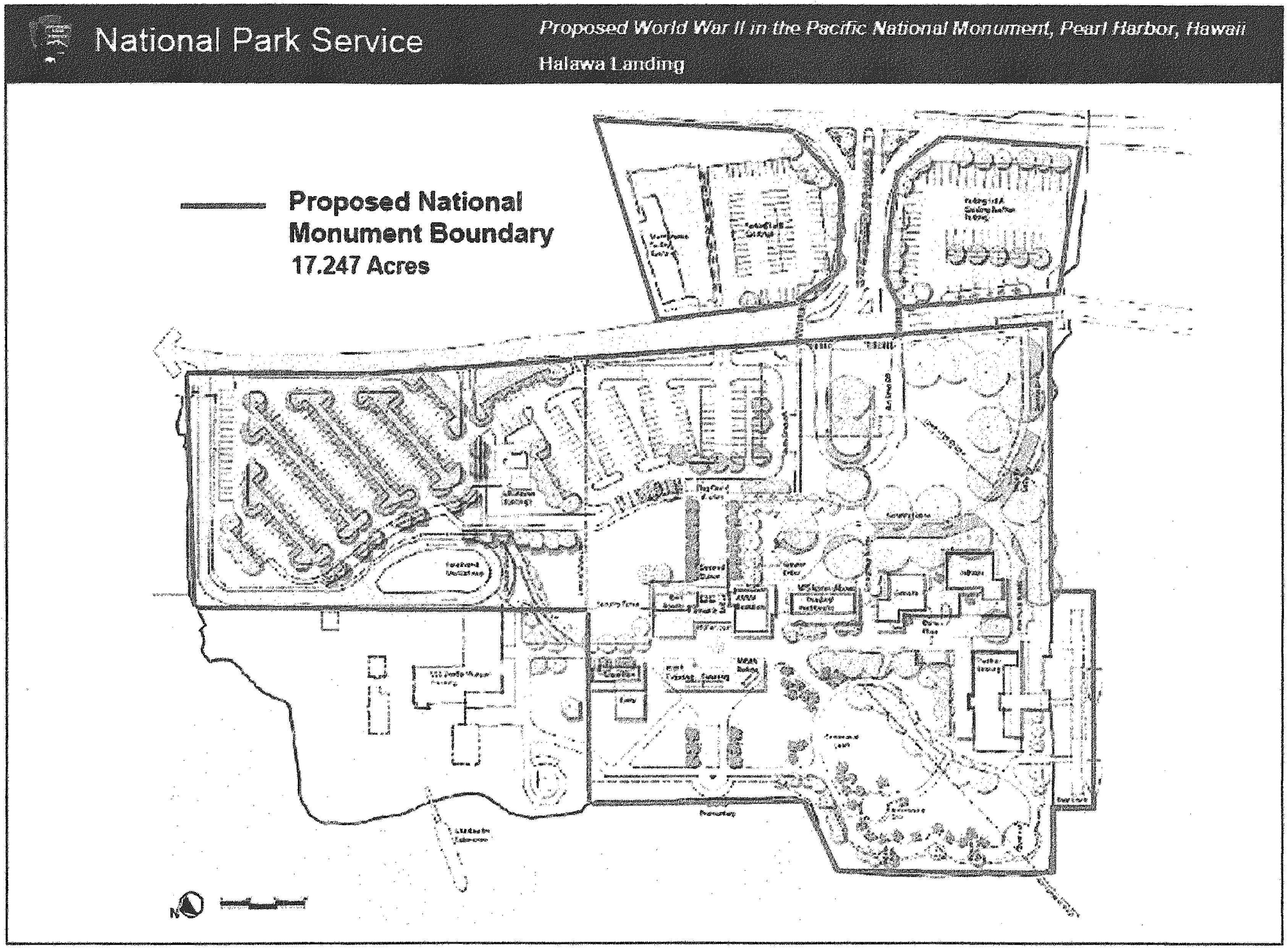
Map C – Attu Island



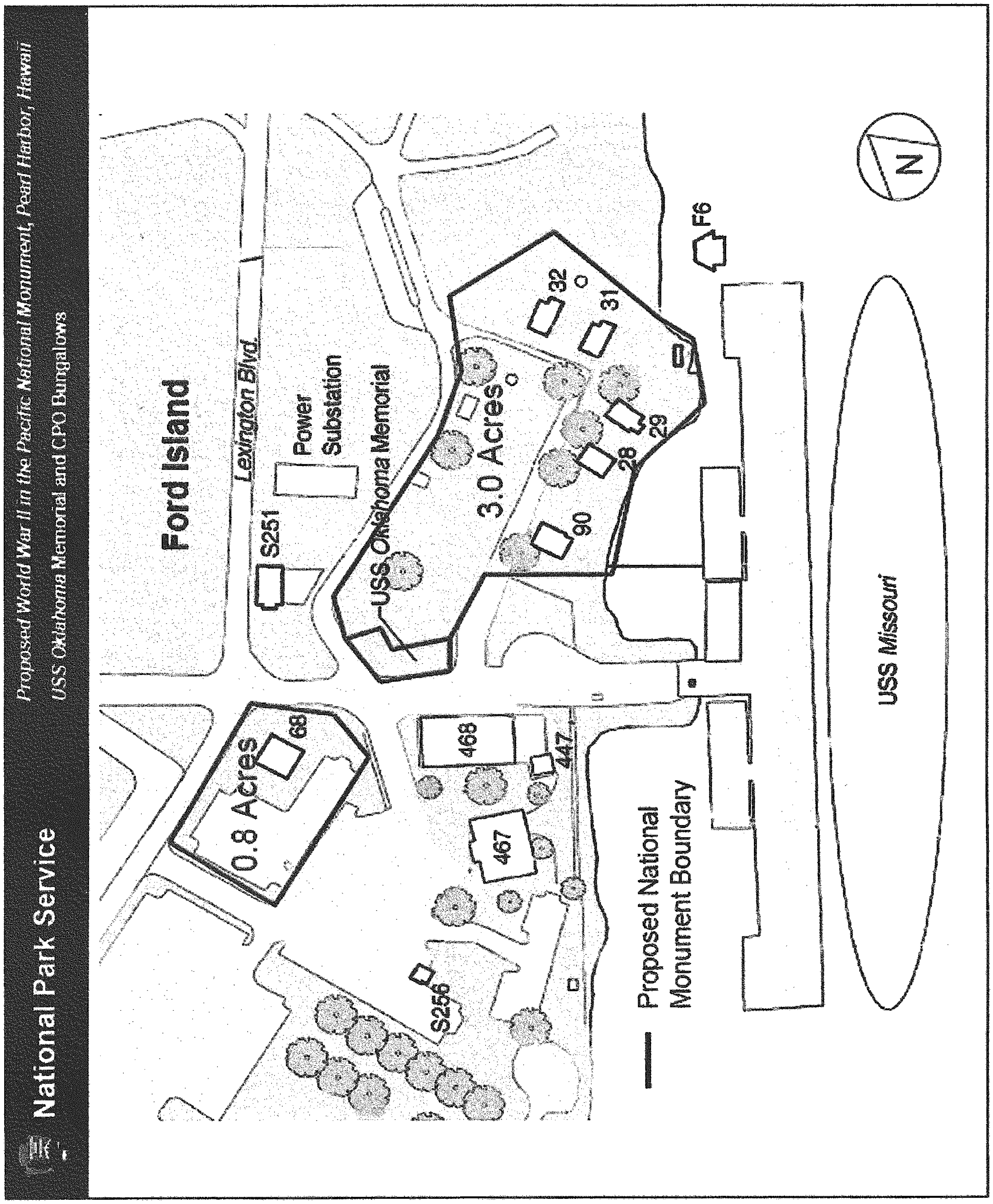
Map D – Tule Lake



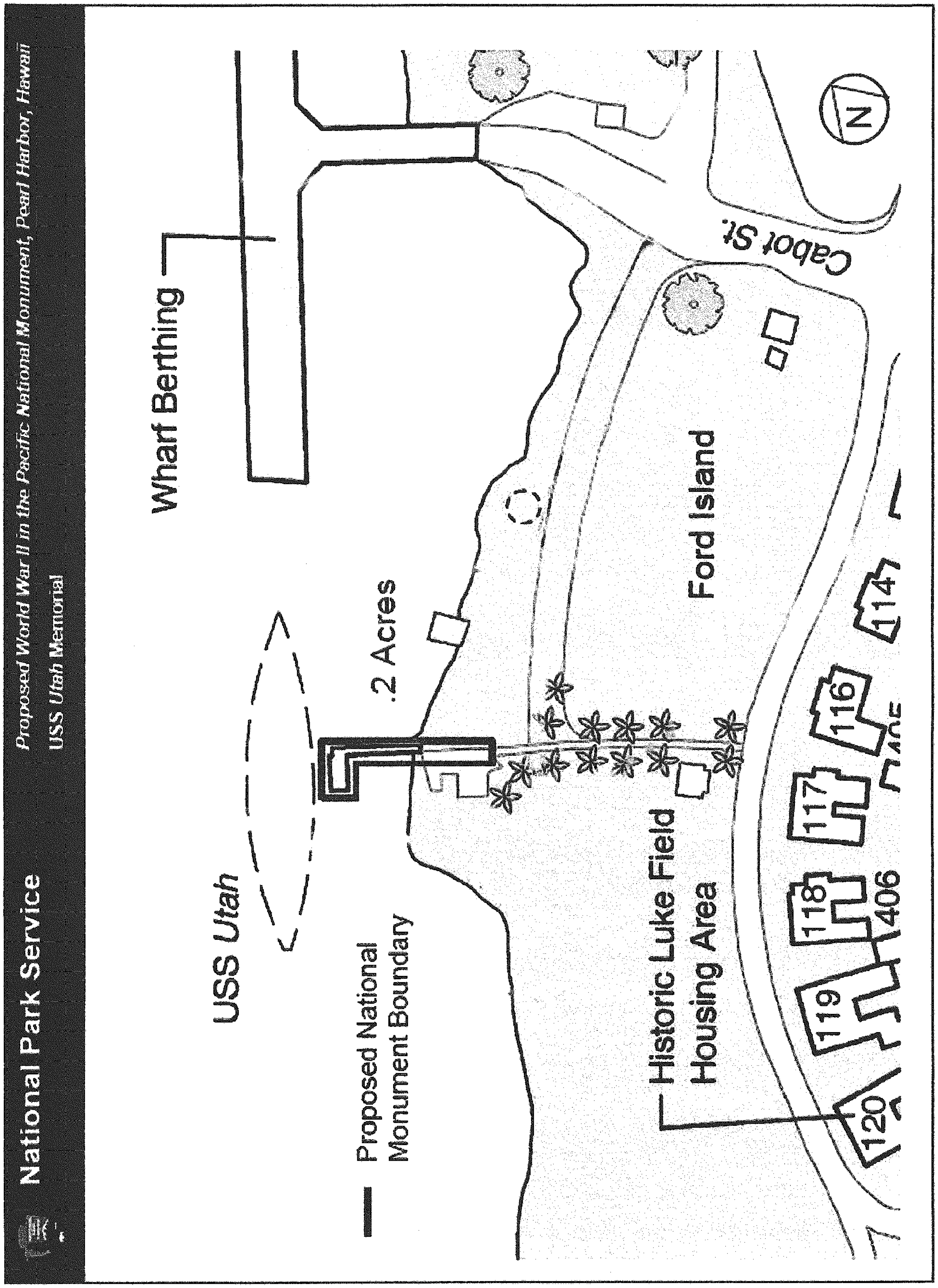
Map E - Halawa Landing and Pearl Harbor Visitor Center



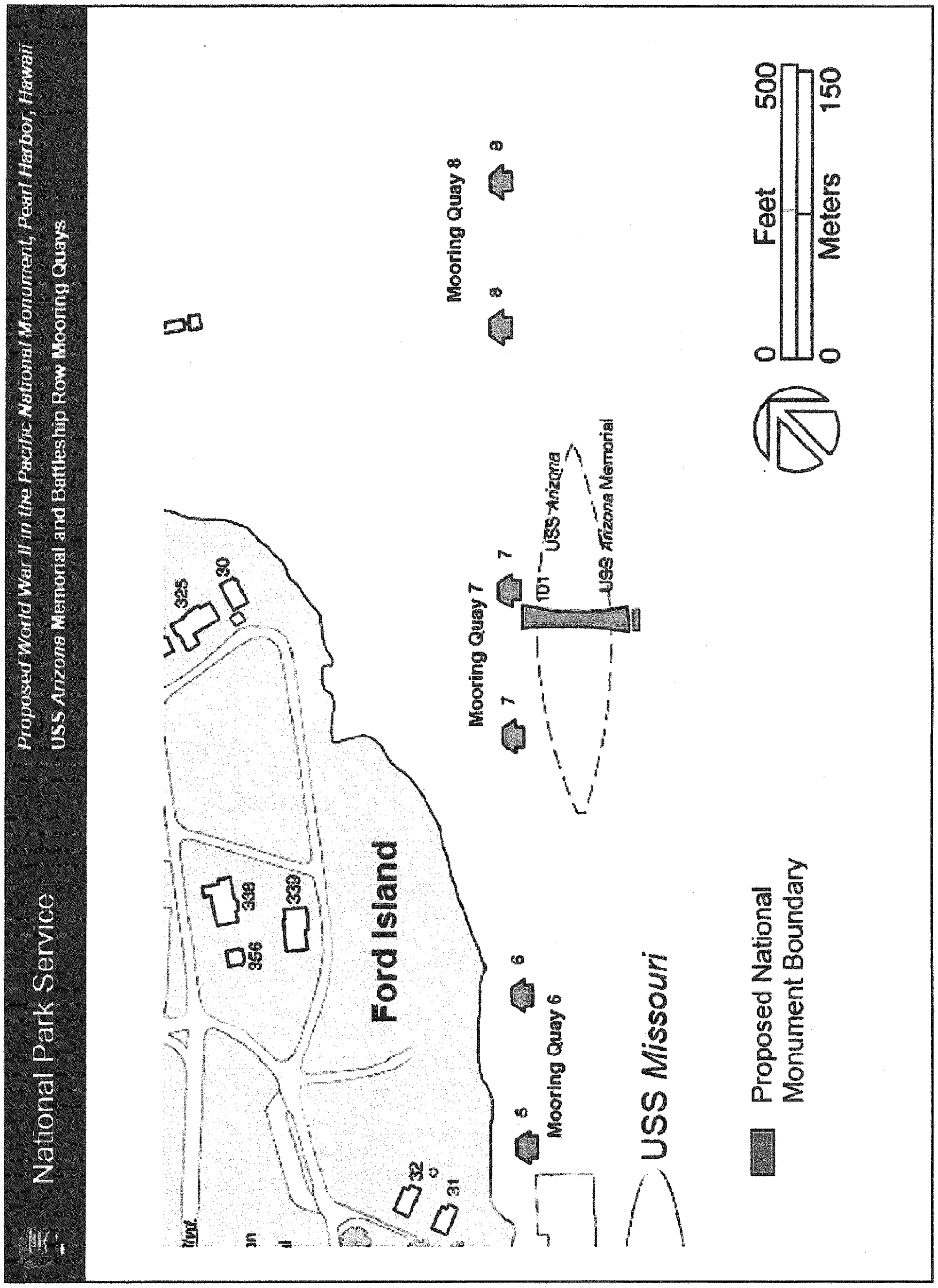
Map F - Bungalow and USS *Oklahoma* Memorial



Map G - USS *Utah* Memorial



Map H – USS *Arizona* Memorial and Mooring Quays



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